A

SELECTION OF PAPERS

ON THE SUBJECT OF THE

FIXED

LIGHTNING CONDUCTORS

TO THE MASTS OF

His Majesty's Navy;

CONSTRUCTED SO AS TO

PASS FROM THE TRUCK TO THE KEELSON,

AT THIS TIME CREATING PUBLIC DISCUSSION.

ILLUSTRATED BY ENGRAVINGS.

TOGETHER WITH

MUCH INTERESTING MATTER ON THE SUBJECT OF

ELECTRICITY;

INCLUDING

HINTS FOR THE PREVENTION OF ACCIDENTS BY LIGHTNING;

SOME OF THE MOST REMARKABLE ELECTRICAL PHENOMENA;

AND VARIOUS AMUSING AND INTERESTING EXTRACTS.

By W. P. GREEN, Lieut. R. N.

London:

PRINTED FOR THE AUTHOR;

AND MAY BE HAD AT NO. 10, LYON'S INN, AND NO. 54, KENNINGTON STREET, WALWORTH.

[*Entered at Stationers' Hall.*]

1824.

TO

VICE-ADMIRAL

SIR ISRAEL PELLEW, K.C.B.

SIR,

WHILE serving under your command in the worst of climates, I had repeated opportunities, particularly in the Mediterranean, in the West Indies, on the coast of Africa, and that of America, of witnessing such phænomena, as in some measure to justify me in proceeding, as I have done, throughout the discussion which is the subject of the following pages A full conviction of your intimacy with the facts which I adduce, and the many obligations

I am under, have prompted me to this dedication.

When without patron or friend, you kindly extended your protection to me, keeping me in your ship, and obtaining my promotion for zeal during the battle of Trafalgar, and other occasions of enterprise; and your certificates strengthened my claims to the notice of His late Royal Highness the Duke of Kent, under whose auspices I entered the navy, and in whom I have lost a valuable friend. Your condescension has taught me to lay aside the deference due to superior station: nor can I forget the encouragement I received from your countenance and support when my humble opinion was opposed to such an assemblage of influential characters, as might have overawed an individual far better qualified for discussing points of science than myself.

To Admirals Sir Alexander Cochrane, Sir Charles Penrose, Ekin, and Brooking, — Commissioner Shields, — Captains Rotheram and Skene, and the many other Officers and Gentlemen at Plymouth, before whom I exhibited

my ship fitted with the several conductors, — to the Gentlemen, Members of the Society of Arts and Sciences in the Adelphi, (who have twice politely heard me explain, in discussing these matters, whose decisions have confirmed me in my ideas, and who have conferred on me two of their medals)— I acknowledge myself to be particularly indebted : — To them, to you, and to the public in general my labours are now presented, with my apology for the rude composition and want of arrangement which may be found in them.

I shall feel tranquil amidst the shafts of critical malevolence, as it is already admitted that I have in this instance rendered my country an important service ; and if I shall yet be instrumental in preservin g from destruction that to which this nation owes its safety — that which has so powerfully aided to make us the mightiest among the mighty, and to shield us from the attacks of the whole world, — it will be a reward I would not exchange for the brightest diadem. The reflection would throw splendour round a life which has had its full

share of suffering and cruel disappointment; and it would be a happy consolation on my death-bed.

I have the honour to remain,

SIR,

Your most grateful and humble Servant,

WM. PRINGLE GREEN,

Lieut. R. N.

And late Commander of H. M. Brig, Resolute.

August 20, 1824.

INTRODUCTION.

WHETHER the present work—like those bubbles on the passing stream, which float along and then expire—will engross the attention of the public only for a moment, and then disappear, or pass onward to ages which its Author can never reach, events can alone decide. I have not vanity enough to presume that infallibility is impressed upon every sentence I have written: the arguments, however, are the result of conviction in my own mind, from a persuasion that they arise from the fixed relations of things. I have attempted to reason on such facts as are incontrovertible; and to trace the intermediate ideas to that conclusion which I had in view. By those who are skilled in the critical accuracies of grammar, my language may be deemed harsh and inharmonious, and, I am sure, very many solecisms will appear; but the gentleman, the philosopher,

the real critic, and the candid of every description, will, I am persuaded, readily make allowances for those imperfections, when they consider my profession, (twenty-four years of my youth having been passed in active service in the navy,) and the many other disadvantages under which I have written. I publish with diffidence; I solicit no favour which justice and candour will not entitle me to claim, and, therefore, none but what I am convinced the public are ready to bestow. The importance of the subject encourages me to proceed: if I succeed in my main object, I shall feel myself greatly recompensed, and trust I shall then have performed a duty I owe to my country and myself.

That I have said all that might be said, or anticipated every objection which might be started, I do not mean to assert: but truths can never oppose each other; and if the arguments and facts which I have adduced be conclusive, every objection, however plausible, must lose its force. On such a subject as this, new ideas may be continually starting, in contemplative minds; and whether its importance, or capability of extension, be the greatest, it is, hard to say; but it may be observed, that he who advances any thing new, in favour of an important subject, contributes to the general stock of argument; and, as his endeavours tend

to increase the knowledge, so they add to the general benefit of mankind.

There appears not a shadow of doubt, in the mind of every person who has enquired into the facts, as to my having saved considerable sums of money, that would have been expended in fitting the fleet with fixed lightning conductors to their masts—that I have prevented the risk attending the ships so fitted, and the chance of the lives of their crews being sacrificed to experiment: but a more important object I have yet to accomplish:—it is no less, than to endeavour to prove what I have advanced, as my humble opinion, respecting the dangerous situation of the Navy at Plymouth, and also of the Naval Arsenal and powder magazines, and their consequent fatality: which may induce persons more competent than myself, to shew whether I have or have not a mistaken view of these most important questions.

As respects the conduct at first adopted towards me, and which it is indispensably necessary that I should explain, I can only account for it by supposing that persons may, under the sanction of philosophy, impose upon the credulous and the unthinking—that, in a delirium of the mind, we may become captivated with the novelty of an idea; we may be pleased at witnessing experiments; and, by adopting

sentiments which originate a few shades beneath the surface of things, a superficial mind is tempted to place the reasoning by which it has been seduced, among the recondite depths of science. One person, (who is favourable to the plan of fixed conductors,) by way of derision, asserted that "I could not be a man of any respectability; because a meritorious officer, as I presumed to be, and one who had long commanded one of His Majesty's ships, would not be permitted to remain so long upon the Lieutenants' list;" making many other remarks, which I dread the consequences, should I repeat: indeed such persons are always so cowardly as to select those for their scurrilous abuse, who, they feel assured, have no means of confuting their defamation. Another, enquiring of a friend, (Captain A—— of the navy,) respecting the result of my appearance at the Plymouth Institution, and of my putting queries to Mr. Harris, was pleased to exclaim, when my name was mentioned—"That Green is evidently touched in the upper-story; he must be a fool and a madman, for differing in opinion with the philosophers, and for his presumption in advancing objections in the face of repeated and approved experiments, particularly under existing circumstances!" Great and mighty men! if you knew that your pride

is the result of ignorance and impudence combined, you would, no doubt, think more humbly of yourselves, and admit that I claim nothing more than fair discussion:—but if you wish to be informed, it is necessary you should know, that he is the truly great man, who assumes no authority over his inferiors, and suffers no pretended superiors to assume an authority over him—who believes himself to be made in the same mould with the rest of mankind; and to be neither better nor worse, but as he is rendered so by his own unborrowed and untransmitted virtues; those virtues which Fortune can neither give nor destroy. The greatness and the virtues of every individual depend upon himself, and are placed completely within his power. From adventitious circumstances—from the mere accident of being a peer, a duke, or an emperor—he can claim no merit: he did not influence the act by which he became their descendant, and therefore derives no merit from that, to which he was not accessory.—

"Worth makes the *man*, and want of it the *fellow*."

To bear calamity with resignation, and to draw cheerful inferences from adverse circumstances, is said to form a very important feature in moral philosophy; and forbearance is said to

be a great virtue, which I am very willing to acknowledge: but there are cases, in which forbearance may almost be considered criminal, and this I humbly conceive to be one of them. It is not in nature, to be continually subjected to unmerited odium, and treated with neglect and contempt, without repining. I can refrain no longer, and I doubt not but it will be universally acknowledged, that such unwarrantable attacks (particularly those in the reply to my queries,) and such conduct as has been pursued, are calculated to rouse the indignation of the most low-bred and unfeeling mind: but mine has been more particularly wounded; and, whatever can and may have been imagined, I trust I am capable of drawing just conclusions from circumstances and facts. I beg to inform some persons that, had my family their just due, I should rank as brother to a Peer of the realm, and, probably then enjoy all the advantages influence can obtain; and, although in my present humble circumstances, I feel myself raised far above them, not only from respectable lineage, but all that which constitutes a gentleman; while I despise the sycophant, and overbearing upstart.

I now appeal to all the officers of the Navy, East India and Merchant Service, to philosophers, and to every individual in this kingdom.

Indeed those who witnessed the phænomenon at Margate, and, recently, the quantity of electrical fluid discharged from the clouds, above, and to the northward of the Metropolis, can form a tolerably accurate idea of the matter now in discussion, and whether I am or am not right in supposing that it is dangerous, at such times, to invite lightning to ships and buildings: that houses and ships having conductors attached to them, are more liable to be struck, than those without any; and that the many ships fitted with spindles, as described in this Essay, are placed in a dangerous situation.

When principles appeal to our passions, under the auspices of reason, and yet leave the understanding uninfluenced by their efficacy, they carry with them a presumptive evidence, that error lies concealed behind the mask.

My object has, all along, been to arrive at truth: not to offend one individual—not to endeavour to excite the admiration of my readers, by nicely selected quotations, and a display of affected ability. I have given my ideas as they rose in my mind, in my usual undigested and roving way, without attending to rule or order: nor is it now in my power to bestow £95 per Cent. upon book-makers, printers, and publishers, to induce them to puff off my labours—for which I shall be entitled to the remaining £5:

and, perhaps, after all this, when I presented the production to those, who, I think, ought to be the greatest supporters of it, they might say, "it is of little value;" and thus leave me in a still more perplexing dilemma. It is not my present intention to attempt a delineation of the pleasures and pains to be derived from such an undertaking; particularly as I do not conceive myself fitted for the task, never having seriously made up my mind to write a book on such a subject as the present one; which, however, according to my humble comprehension, and what I learned at the Plymouth Institution, is not so extremely difficult in modern times, especially if the word "*write,*" be altered to "*compile:*"

I have endeavoured to produce several Treatises on my profession; having a very open field to range in, in which no one had gone before me, and I consequently found it to be filled with tares, which gave me much trouble to get rid of.* Some persons say, my productions possess novelty — an important ingredient, certainly, in the composition of an occasional lucubrator, and one of the leading requisites to obtain a patient perusal from the reader. Yet

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* The Reader is referred to a list at the end of the book.

I have never ventured to give my labours publicity, fearing their humble origin would bring discredit and contempt upon them: and no wonder — as they were born and begotten by the light of the binnacle; Hamilton Moor their grandam, and an old silver pen their foster-father. Nor did they ever, until this period, see the light, being mostly of the mid-watch production: others composed under the torture of the scraping of a fiddle, or blowing of a flute, out of tune and out of time, with numerous other whizzing noises, which created a serious effect on my nerves, that I have never been able to throw off. Indeed I sometimes fancy, if it were not from the recollection of Nelson's last words to us at Trafalgar, "England expects every man to do his duty"—and having, I hope, done mine there and during the last twenty-five years of my life—I might have neglected this important part of that duty.

The following are the data upon which I rely, in the succeeding pages:

1. That the quantity of electric matter in a cloud, which a conductor is liable to receive, is always uncertain; and most frequently, especially in tropical climates, more than any conductor could control.

2. That a fixed conductor from the truck of the mast to the keelson is highly objectionable, as, in the event of being overcharged, the destruction of the ship is certain; the electric fluid then flying off to adjacent bodies which most strongly attract it—indeed, into the midst of the powder magazine and combustible stores of the ship.

3. That if any conductor be used, one that leads the electric fluid outside the vessel, is least liable to objection: such is the chain conductor hitherto in use.

4. But that it would be more prudent not to invite the lightning at all,—as casualties are less frequent where conductors are not used, than where they are.

5. That placing the spindles in the top of the masts of his Majesty's fleet at Plymouth, is a dangerous plan; because they will conduct the electrical fluid into the body of the masts, splinter and fire them.

ESSAY.

ABILITY, it has been contended, and may be maintained, is a saleable article, which the owner has a right to offer at the best market, and to dispose of for his own benefit. Of this subtle mode of reasoning, and of such arguments as have been advanced in support of the plan for fitting the masts of his Majesty's fleet with copper conductors, the fallacy has been nevertheless shewn; for though talent may be a person's sole patrimony, the possessor must be responsible in every way, notwithstanding, for its misapplication.

I do not pretend to be exempt from fault and error myself; it would be a miracle to escape them when discussing matters like the present: nor have I the least idea of deciding as judge, in a case of such vast national importance. No; I appeal to the public for discussion; and only assume the part of an advocate to plead the cause of consistency and analogy; and

where theory or custom is silent or dubious, I would tempt the supporters of both to incline to the side of propriety.

The assemblage of so very many philosophers, electricians, and scientific gentlemen composing the members of the Society for promoting Arts and Sciences, to discuss this matter, has been frequent; and they have, in every instance, coincided in my opinions and remarks herein set forth; as have also vast numbers of practical gentlemen, and other competent judges, who have examined the facts adduced.

Whatever, therefore, may be the arguments of theorists, it must now be allowed, that there are certain deviations from analogy, as respects the nature and action of electric fluid; and as every day produces new phenomena, a practical description like this is likely to merit attention; and it is a display of these analogies, and such means as I pursue, which can alone remove doubts and uncertainties, and prevent the evils which it is my object to avert.

Not that I would deny theory its uses; I acknowledge its authority, and know there is often no appeal from it. I wish only to dispute whatever this arbiter has not decided, and what is admitted to remain a desideratum of great importance.

From what I have experienced, and the notes I have made, in the tropical and other climates, with the variety of different opinions advanced. I am of opinion, that were the whole body of European philosophers and electricians dispersed throughout those climates, there to witness such phenomena as are herein stated, and those of daily occurrence, and each individual to publish his remarks, they would alter many

of their opinions, particularly that of electric fluid being confined to surfaces; and, speaking from what they had personal cognizance of, their variety of statements would confound each other, and astonish the community at large. Therefore, and under such peculiar circumstances as mine, the candid reader will, I am sure, make every reasonable allowance for the freedom with which I have criticised Mr. Harris, on the subject of introducing fixed lightning conductors to the masts of his Majesty's navy. As a gentleman, I know Mr. Harris; and think every lover of science owes him a tribute of thanks for his exertions; for he must have been put to great expence and trouble, and have considered his plans to be good; but this tribute, however just, does not exempt him from examination. His credit, and that of his supporters, with the public, necessarily subject him to animadversion, because their errors are dangerous in proportion to their power and influence. This impression has made me zealous to point out, what, in my opinion, are his inaccuracies; and this I commenced by queries, and would complete by discussion, carried on, I trust, in the true spirit of inquiry. Indeed, the facts contained in the following pages amount to so strong a confirmation of what I herein advance, that, if I am not very much mistaken, my justification might rest upon them alone, though nothing more should be adduced; but I feel, should I not at this time give this production publicity, I should be guilty of a breach of duty so infinitely serious, as to render its consequences to my country and myself almost incalculable.

An order having recently been issued at Plymouth dock-yard, to discontinue the fitting of the masts of his

Majesty's ships with conductors for lightning, after the plan of Mr. Harris, is ample proof of the services I have in that instance rendered my country; and a MS. copy of these remarks being entered on the records of the Admiralty, induces me to imagine that they possess some importance. To my queries, and the reply made to them, I beg leave to refer the reader; and at the same time intreat his most serious attention to my present object, and the opinions now advanced.

A man may aim at something, indeed, and have honest designs in his head; and, as in the present instance, have many to support him from a variety of views; but this is not to lead others, who are not satisfied with theories, to act according to mere appearances of things, and to be contented with a superficial view of them.

I here positively declare, that notwithstanding all that has been asserted in reply to my queries, private enmity is out of the question; and should any thing herein be supposed to have arisen from so ignoble a passion on my part, it must in candour be admitted, that it has been conducted at least with personal manliness. Personality, especially in public discussions, should always be avoided; but when either party makes use of such an unworthy mode of answering his opponent, he cannot expect to be treated with the courtesy of an ordinary disputant.

When the subject of the following pages was first agitated, I felt deeply interested in it, and, to promote discussion, laid before the public a series of queries through the press. My first queries and request, put to Mr. Harris through the Plymouth Dock Telegraph newspaper, had, for some time remained unanswered,

when he invited me to his lecture, at which I appeared for the purpose of stating my views of the subject. But when called upon by the President, I naturally solicited permission to read the queries; with a view of entering fairly into the question, by taking it up in an early stage. This was, however, denied me; and every difficulty thrown in my way.—Now, any man, however well acquainted with his subject, when opposed to such a host of the learned and powerful as were present at his lecture, might for a time be made to appear in error. The opposition and clamour were great. I had to combat, single-handed, an audience who appeared to have prejudged the question, supported as their decisions had been, upon the calculations and experiments of the learned. Nothing but a thorough conviction of the fallacy of their theories, and a sense of the danger which the many might be exposed to, could have given me confidence sufficient to stand forward and maintain my opinions against such an assembly. Is it therefore to be wondered at, that, though conviction was produced in the minds of the majority, shafts of envy should have been thrown at an unprotected individual, who had thus put aside their favourite scheme?—but who will rest satisfied in the assurance, that he *alone* has since pointed out to the public, that his Majesty's fleet in ordinary, at this time at Plymouth, in value little less than three millions, is tottering on the brink of destruction, as a single cloud fully charged with electric fluid, may in an instant set it on fire. Centuries have passed without resorting to such means for protecting the navy, and little or no damage has occurred; and where any accident has happened, it has been traced to have been caused by metal

spindles or other pointed attractors of electrical fluid receiving an overcharge.

In a second discussion on this subject, I again appeared before the Society of Arts, with the model of a ship completed with the three different conductors alluded to. Before that Society and numerous other competent judges, I explained my objections to the proposed plan; and on this occasion, my reasoning met their unanimous concurrence.

It is now proper for me to explain and set forth the opinions of those who have discussed the matter.

I contend, that such a powerful invitation as the metallic spindles, placed as fixtures, one in each of the three mast-heads of the ships before-mentioned, screwed six inches down into the solid timber, and there being several hundreds of the like powerful attractors in a small compass—will not only draw sufficient electric matter (that would otherwise have passed silently on in the clouds) to effect the destruction of the ships at Plymouth; but probably the naval arsenal and powder magazine also.

Differing, as I do, in opinion with those who contend that the power of electricity is always confined to surfaces, and passes from one surface to another, I should expect some opposition, had I not the evidence of positive facts to the contrary.

I have adduced instances of metal bars, two or three inches solid square, receiving an overcharge of electric fluid, which expands and occasions them to become hollow tubes; of a bar, of equal dimensions, being melted, as if it had been lead placed over a fire; of large iron hoops round the mast, eight inches deep and one inch thick, being broken in pieces, and

reduced in substance to small wires; and of sand tubes being formed, by lightning, thirty feet below the surface. Having referred to repeated phenomena to confirm all this, surely it is no more than reasonable for me to come forward, and declare my well-founded alarm for the safety of our fleets and arsenal.

No subject in nature has undergone a greater variety of opinions than the theory of electricity; and in the present day, it appears that the ideas of philosophers, theorists, and those who, in tropical climates, frequently witness the unaccountable action of electric fluid when discharged in quantities from thunder clouds, are much divided with respect to its quantity and the modes of its action. Perhaps an attentive observation will lead us to conclude, that what ought to direct us in determining this matter, is neither theory nor practical observation taken singly, but a sort of compound ratio of both.

There is no impossibility in the supposition that the same ponderous matter in different electrical states, or that a varying quantity of electric fluid attracted to metals, may constitute substances and effects chemically different, and the specific attractions of bodies and definite proportions, must, therefore, remain undetermined.

To the spindles used on the tops of the masts, a conducting chain is placed; one link of the chain being passed over the end of the spindle, and extending over the ship's side into the water. The conductor at present used in the navy, is a chain having the spindle attached to it; this conductor, when used (which is very seldom, from the prevailing opinion that they are of no use), is hoisted up to the extreme, or highest

point of the mast, by a rope for that purpose: this spindle or chain not being connected with the mast, nor ever touching it, and being six inches above the mast head, as will be seen in the plate, leads me to suppose, that, if any conductor be of service, the latter (which now lie in thousands in our naval store-houses) is the less likely to damage the mast, or to conduct the electrical fluid into the body of the ship; and is therefore the best, and most proper to be resorted to.

But I here contend, (and in this I am borne out by repeated experiment and phenomena) that ships and buildings, without pointed conductors attached to them, are less liable to injury than those having them; that the many spindles screwed into the solid wood, will, notwithstanding the link of the chain be round them, conduct the electric matter into it, and an explosion and consequent destruction of the mast must follow.

Again, as lightning must visit the earth somewhere or other, there can be no occasion to invite it to a particular point at all; but on the contrary, when it attacks a ship, if there be any conductors, they should be so contrived as to carry away as much of the electric fluid as possible, but not to attract or promote the increase of its quantity, as the many spindles before described evidently will. In fact, no man ever tried the experiment of having so many conductors in a small compass; and the fact herein stated, of Professor Richmond's one small conductor having such a powerful effect, under peculiar circumstances, will point out the infinitely increased danger of such a multiplied number of conductors. Indeed, if the fleet is not cleared of this invention, it is to be apprehended that disastrous experience alone will determine this point.

Every rope in a ship, when wet, is a conductor for lightning; but not (as metal spindles are) an inviter and promoter of its quantity. There being then so many of these ropes to every ship, all exhausters of electric fluid, no one part being more attractive than another, is, in my humble opinion, the only reason why ships are exempt from damage when without metal conductors; and, as I am also convinced, that the having metal spindles in the masts, or having conductors, is often the cause of damage, and that electric fluid is not confined to surfaces, I shall produce many facts in the sequel, to prove my assertion. Indeed, the Franklinian theory affirms the fact, of electric fluid being attracted by all bodies, and universally disseminated throughout their pores.

If the power of electricity is confined to surfaces, how then is it possible that several of the hoops round a ship's mast, each hoop having a surface of three inches, one inch solid, and twelve or more feet in circumference, as stated in my queries, could be twisted and broken at the same moment, and this, too, by a single flash of lightning?

From the well-authenticated facts, as will appear in the sequel, of bodies most elevated, echo from cannon, and other noise, having a tendency to cleave the base of a cloud, and thereby facilitating the fall of the exhalation upon them; that the exhalation is by the wind carried above our heads, to the tops of trees, houses, &c.; and that the electric fluid is known to cleave and root up trees, uncover belfries, throw down parts of churches and houses, drive up stones and earth for a considerable distance, and even destroy parts of mountains; I have been induced to suppose that the attrac-

tion of the high mountains surrounding the fleet at Plymouth, with the firing a salute at the time of thunder and lightning, would weaken the base of the clouds; and from the additional powerful attraction of so many metal conductors on the ships' masts in the harbour, the discharge of electric fluid would not only be great, but in mild weather occasion the clouds to become a fixture over the ships, until the fluid had exhausted itself, and by that means set them all on fire: and in this opinion I was the more determined from the occurrence stated in the sequel, of the effects of lightning at Margate, and in the case of his Majesty's ship Cleopatra, and others.

The custom used at sea of dispersing a water-spout, when approaching a ship with the appearance of certain destruction, is another inducement for me to form such an opinion. On the approach of a water-spout, cannon are fired; the echo of these weakens the base of the cloud, and occasions the lightning, which often accompanies the cloud and the water-spout, to disperse and disappear. Here it may be proper to explain the cause of echo. An echo is caused by the vibrating air being obstructed in its passage, for as the air rolls or passes along like a wave, it often meets with various objects, and striking against them, is reflected back and causes new vibrations. Whirlwinds tear the masts out of ships, cleave trees, acting upon the branches as upon as many levers, uncovers houses, &c. An exhalation being more gross and more rapid than the whirlwind, does so also, with the difference, when it strikes a wall or sand beach, that it calcines them, and insinuating itself into the unhewn stones, there acts as powder in a mine, and violently pushes down the wall: its wonder-

ful effects upon sand and walls are set forth in the Appendix.

It is well known that lightning will sometimes break the bones, and not injure the clothes; that it will break a sword in the scabbard, and not hurt the scabbard, &c. &c. The reason some philosophers give is, that the particles of light in different flashes are different in the respect of their figure and quality; but I should think it rather proceeds from the intensity of them, and the incredible velocity; for the greater the velocity or celerity, the greater the stroke or force.

Persons are killed by lightning without contusion; they die from suffocation, owing to the sulphur stopping the passage of respiration: when this is the case, they have no perceptible wound or mark.

Many may be induced to peruse this tract, who may be desirous to be better informed of the cause as well as the effects of lightning, which induces me to give the following short Essay. It consists of extracts from my remarks, what I have witnessed, and what I recollect to have read.

Amongst other assertions made in the attempt to refute me in argument. It was declared that the quantity of electric fluid in the atmosphere, and the power of attraction, may be determined by an electrometer. In reply to this, I have referred such as are under that persuasion, to facts set forth in the sequel. Indeed, a reference to the night of the 13th of July of the present year, fresh in the memory of every individual in the metropolis, is alone sufficient to confute such argument.

ESSAY

ON THE CAUSES AND EFFECTS

OF

LIGHTNING,

&c. &c.

That kind of electric matter which makes the greatest havoc is observed most frequently to take fire in the upper regions of the air, whence it slants downwards towards the earth, and often directs its force against some attractive point, such as trees, churches, metal conductors, or other eminent objects, on which it produces such surprising effects, as set forth in the sequel. Those more noxious blasts proceed from the gradual rise of matter proper for fulmination out of the earth, particularly in stormy seasons; the upper parts of which, meeting matter formed in the air, ferment and take fire, pursuing the track of the rising vapour to the very end; and here it is probable the force of the whole blast does concenter, with such a resistless and impetuous force as may dissolve one hard body, calcine another, perforate a third, entirely change the constitutional parts of a fourth, giving them the variety of different directions, observable to the spectator. The bituminous and sulphureous particles occasion the

flash; the saline and nitrous particles are said to cause the noise or explosion, as appears from the property of gunpowder. What is called thunder may be produced by the sudden and violent motion of the air adjacent to the flash, endeavouring immediately to thrust itself into the vacuity thereby made.

From the continued length of a clap of thunder, and from the various loudness of it, it may be concluded that the lightning really is a track of running fire, which, though it may seem to be instantaneous, and to fill the hemisphere with flame at the same time, yet is propagated successively, as appears by the approach and receding of the sound thereby produced to the ear with a different force, as if proceeding from different distances.

How far off, or how near we are to the danger attending lightning, may be estimated by the length of interval between seeing the flash and hearing the clap of thunder; for though they are almost instantaneous, and both produced in the same moment, yet light moving by many degrees faster than sound, they come to our senses, and affect our nerves successively. Light is discovered to move progressively at the rate of about ten millions of miles in a minute, or 1,500,000 times faster than a ball discharged from a cannon; so that we may very well take the time of our seeing the flash for the instant of the explosion. Electric fluid moves as rapidly as light; sound moves at the rate of 1100 feet in a second of time, that is, one million three hundred thousand yards, or 7500 miles in an hour: so that by holding and counting the pulse or seconds of a watch the moment of seeing the flash, we may calculate its distance. The clap which always succeeds

the lightning is generally followed by a fall of rain, because the inflammation which causes the noise shakes and dissolves a part of the cloud, which falls down in rain, and when rain abounds it seldom thunders any longer, because the rain falls upon the exhalation, drowns it, or carries it off in great measure.

As clouds are formed from exhaled vapours, the same power in nature which attracts them from the earth draws them towards each other, so that a kind of aqueous conducting chain is formed for the passage of the fluid from its receptacle the earth. Thus may electricity be transmitted from one part of the earth that is surcharged to another that is deficient. The quantity contained by the clouds is in such vast abundance, that although particular clouds are perpetually discharging the collected matter to the earth, yet the unbounded stores of the earth instantly supply the deficiency, so that the clouds continue to discharge the electricity, with a short intermission, during the whole time of a thunder storm, or till the electricity is restored to an equilibrium.

Some imagine that the clouds do not receive their electricity from the earth, but from the heating and cooling of the air ; so that the clouds, in passing through a rarified part of the atmosphere, receive electricity from it, and give it back again to those parts which are in a more condensed state. Others have conceived, from the sultry state of the atmosphere in thunder storms, that electric matter is generated by the fermentation of sulphureous vapours with mineral or acid vapours in the atmosphere : thus shewing that much concerning the power of electricity still depends upon hypothesis ; and, although great advances have been

made, yet much remains to be ascertained. We still see through a veil, but such phenomena as are set forth in the sequel must in time withdraw this curtain which evidently is before our eyes: the opinions of philosophers will then be one and the same, the wonders of electricity be completed, and its effects discovered, not only in the laws of planetary motion, but likewise traced to its source in meteorology, magnetism, vegetation, muscular motion, and all the economy of nature.

Dr. Franklin's Experiments.

It had been imagined that a similarity existed between lightning and the electric fluid; but Franklin brought this supposition to the test, and proved the truth of it by the simple means of a boy's kite.

It was not until the year 1752 that Doctor Franklin, so famous for his electrical research, was enabled to complete his discoveries by experiment. Whilst he was waiting for the erection of a spire for his purpose, it occurred to him that he might have more ready access to the region of clouds by means of a kite. He prepared one, by attaching two cross sticks to a silk handkerchief, which would not suffer so much from the rain as paper. To his upright stick was affixed an iron point. The string was, as usual, of hemp, except the lower end, which was of silk: where the hempen string terminated a key was fastened. With this apparatus, on the approach of a thunder-gust, he went out into the commons; the kite was raised, and for a time he despaired of success, when suddenly he observed the loose fibres of his string to assume an erect position. He now presented his knuckle to the

key, and received a strong spark. By this simple means he proved that the electrical fluid which produces lightning was exactly the same as that which he obtained from his electrical machine.

On this experiment depended the fate of his theory. If he succeeded, his name would rank high amongst those who had improved science; if he failed, he expected to have been subject to the derision of mankind, or, what is worse, their pity, as a well-meaning man, but a weak silly projector. By these and other experiments Franklin's theory was established in the most firm manner. When the truth of it could no longer be doubted, the vanity of men endeavoured to detract from its merits. That Franklin, a native of Philadelphia, the name of which was hardly known, should be able to make discoveries, and to frame theories, which had escaped the notice of the enlightened philosophers of Europe, was too mortifying to be admitted.

Besides these experiments, Franklin's Letters on Electricity contain various facts and hints, which have contributed much towards reducing this branch of knowledge to a science.

In consequence of such experiments, pointed conductors for a time became very common in America; but their being melted, broken, and otherwise reduced in substance, and such repeated phænomena as herein set forth, have prevented their general introduction there or in Europe. Indeed it is proved that such conductors are not sufficiently large to conduct so great a quantity of lightning to the earth as was often drawn to them; and, instead of conducting the lightning, they have been melted by the explosion; and a conductor of metal less than six or eight inches in

breadth, and a quarter of an inch in thickness (or an equal quantity of metal in any other form) cannot be depended on when lightning is *not* severe. Electrical clouds have an electrical atmosphere, as well as the prime conductor, when it is electrified; and the diameter of that atmosphere will bear some proportion to the size of the cloud.

Electricity.

Electricity is that power or property which some bodies possess of attracting light substances when they are excited by friction. Amber, sealing-wax, resin, glass, and the tourmalin (which is a red-coloured transparent fossil found in the island of Ceylon), are of this description.

The attractive power of amber was known some centuries before the Christian era, but it was then considered as a mere quality which was attached to that peculiar body. But electricity is now supposed to be a primary agent of nature, which is diffused throughout the whole atmosphere, and enters into the minutest pores of bodies in general. Thus the electric fluid, which had escaped investigation for many years, is now become a principal object of science. About 1745, we find the knowledge of this subject diffusing widely under the splendid talents of Watson, Canton, and Priestley, in London; Franklin, in America; and the Abbe Nollet, in France. In the hands of these philosophers electricity has made more progress in a few years than it had gained in all the preceding ages. It was at this time that the mode of accumulating electrical fluid on the surface of glass was carried to its greatest height, by

means of what is called the Leyden Vial, from the birth-place of the inventor, who was a native of Leyden; but the greatest discovery that was ever made in electricity was reserved for Dr. Franklin, in America.

The present opinions in electricity are principally divided into two parts: one relating to what is called *vitreous* and *resinous*, and the other to *positive* and *negative* electricity. The former of these opinions was first laid down by M. du Foy, and was afterwards new modelled by Symer; but it is now generally rejected. This theory supposes that electrical matter is formed by two distinct fluids, which are repulsive with respect to themselves, but attractive to one another; and the electricities are called vitreous and resinous, from their reciprocal affinity to glass and resin. It is further supposed, that those fluids are attracted by all bodies, and exist in intimate union in their pores, without any external mark of existence, until the two fluids are brought into action by a separation of their parts, which is produced by friction. When those electricities are collected and separated by the attrition of the rubber on the surface of the cylinder of an electrical machine, the vitreous passes over to the prime conductor, whilst the resinous is drawn to the rubber. In this state of separation they exist in their respective qualities; so that by electrifying light bodies with each kind of fluid, those that possess the vitreous will repel each other, as well as those which are mutually electrified with the resinous: but if two bodies, which are oppositely electrified, be brought nearly together, they will attract each other, and give and receive, at the same moment, an equal portion of their respective electricities. According to this theory, the electric spark has a double current, and

the electrified body will receive from any conductor in the electrical atmosphere, an equivalent of the opposite fluid to that which it gives ; so that if the finger be presented to the prime conductor of the machine, whilst the body inhales the vitreous stream from the conductor, it gives an equal stream of the resinous from the body : those quantities are so exactly alike, that a light body may be suspended by the opposing forces between the end of the finger and the conductor.

The preceding subject embraces the immediate outline of the double current, or what is called vitreous and resinous electricity. The other theory, of positive and negative electricity, was first taken up by Watson, but was afterwards illustrated, digested, and confirmed, by Franklin, and thence it is called the Franklinian theory. It supposes that the whole phænomena of electricity depend on a subtile and elastic fluid, entirely of the same kind, repellent amongst its own particles, but attracted by all bodies, and universally disseminated throughout their pores. When bodies hold their own natural quantity undisturbed, they are called in a non-electrified state ; but when the natural quantity of fluid in a body is disturbed, either by adding more to that which it naturally possesses, or by taking away a part of its natural quantity, it has an electrical appearance, or is in an acting state. When a body possesses more fluid than its natural quantity, it is called *plus*, or *positive;* and when it contains less than its natural quantity, it is called *minus*, or *negative*. The progress of this fluid depends on the nature of the body through which it passes : those which give it the greatest facility in its course, are called *conductors* ; and the fluid is instantly transmitted through them, even to the greatest dis-

tances: those bodies, the pores of which will not admit the transmission of electrical fluid, are called *electrics*, and are impermeable; so that there cannot be an accumulation on one side, without a deficiency on the other: and when the two sides are joined together by a proper conductor, the superior, or positive quantity, rushes through it to the inferior or negative, till the fluid on both sides of the body is in equilibrium. or in its natural state. When an electric is rubbed by a conductor, (as the friction of the rubber upon the cylinder of an electrical machine,) the fluid is carried from one to the other, and the rubber will be electrified negatively; but, as an insulated cushion only affords a small portion of electric fluid, a conducting chain is connected with it, which gives a constant supply, from the negative to the positive side. Thus it is conceived, that bodies differently electrified will readily approach; but that those which are equally charged, have an equal repellency.

Having thus stated the principal features of the two prevailing theories, it would be unnecessary to follow them both: I have, therefore, preferred the latter; not only from its more general acceptation, but because it likewise possesses a simplicity of principle, which appears consonant to the general operations of nature. The compound quality of the fluid, double currents, and opposing action, of the first theory, stand unsupported by any other phænomena of similar principles, in the operations of nature: but the latter has a strong coincidence with the system of elastic fluids in general. Before we enter into the experimental proofs of positive and negative electricity, it will be necessary to introduce some preparatory knowledge on this subject.

First, of the existence of the electrical fluid: If a glass tube, about an inch and a half in diameter, and three feet in length, be rubbed briskly with a piece of leather, in a darkened room, small divergent flames will fly off with a crackling noise, and sometimes a spark of fire, six or eight inches long, may be seen following the hand upon the surface of the tube. If a brass ball be suspended from the tube by any conducting body, (such as a piece of wire or thread,) the electric fluid will descend through the conductor and electrify the ball, which will give a spark to the knuckle, or electrify any light body that is presented to it. When the ball is suspended from the tube by a silken string, instead of wire or thread, the excitation of the glass will produce no sign of electricity in the ball; and if the down of a feather, or any other light body, be presented to it, it will remain unmoved; for, as silk is not a conductor, the fluid cannot pass from the glass to the ball. Thus, with respect to electricity, all bodies are divided into two kinds, called conductors and non-conductors, though, in point of fact, no body in nature can be considered purely in that point of view so as completely to transmit or retain the electrical fluid. The general class of conductors comprehends metals, semi-metals, ores, and fluids, in their natural state, except air and oils. Green wood is likewise a conductor, but when it is baked it becomes a non-conductor. Many electrics or non-conductors, such as glass, resin, air, &c. become conductors by being heated. A conductor cannot be electrified if it has any communication with the earth by means of immediate conductors, for then the excited fluid will pass through the conducting bodies and be dispersed.

Insulated conductors are conducting bodies supported or surrounded by an electric or non-conductor, so that the communication with the earth is cut off. A brass ball and thread suspended from a glass tube is an insulated conductor; for, on excitation, the fluid passes from the non-conducting tube through the thread to the ball, where it is retained by the surrounding atmosphere as an electric; or, if the ball be suspended by a silken string, and an excited tube be brought to the ball and afterwards taken away, the electrical fluid which is communicated will remain insulated by the air and the non-conducting body of the silk. The greatest quantity of electricity is obtained by the friction of a conducting body upon the surface of an electric. If the rubber be afterwards insulated, the non-conducting surface will remain charged with the electric fluid, and communicate electric sparks to any conducting body that is presented to it. If a conducting body be insulated and electrified, the whole of the fluid which is collected will be carried off by a single spark drawn by a conducting body: for, as the fluid passes with the greatest facility through all parts of a conductor, the whole flies off at the instant of communication; but non-conductors that are charged only part with that share of their fluid which lies on the surface next to the conductor. A mutual attraction exists between electrified and non-electrified bodies; for, if a light substance be placed near an electrified body, it will fly towards it till it has obtained the same intensity of fluid, then it will be repelled and attracted by any non-electrified body that is near it. If a non-electrified body be set at a proper distance from an electrified body, and a feather be placed between them, the

feather will be alternately attracted and repelled by each; for when it is electrified it flies to the non-electrified body and delivers its electricity; it is then attracted and charged again by the other; and thus it will continue its course backwards and forwards till it has reduced the surplus of fluid in that which is electrized.

Aurora Borealis, or Northern Lights.

The Aurora Borealis, or Northern Lights, are supposed to be produced by the continual discharge of electric fluid; for, in higher and more attenuated parts of the atmosphere, where they are always seen, a large quantity of the fluid cannot be collected by clouds to make a great concussion like thunder, but it is dispersed as fast as it is collected; which gives the perpetual flashing resembling the appearance of electrical fluid in a rarified receiver; for they have the very action of light and lightning, except that these ascend, being light and very fine, while lightning descends with force and explosion.

Falling Stars.

What are called Falling or Shooting Stars are supposed to be produced by electrical fluid passing through the air when its course is not disturbed by stormy clouds; and, by collecting itself to those conductors it may meet with in the air, it becomes visible in its passage to the earth.

Ignis Fatuus.

The Ignis Fatuus is a luminous body, which is seen in the dark, hovering over bogs and marshy places, seemingly both changeable in situation and varying in its appearance. This body is generally considered as inflammable air, arising from the marshes being ignited by electricity. If they fly from you when you advance, that is because you push the air forward which bears them; if they seem to pursue you when you run away, it is because the air which bears them takes possession of the place which you quit.

Fire St. Elme.

Fire St. Elme, which fastens to masts, spars, and ropes of ships after tempests, is a viscous exhalation, kindled upon the sea by the shock and agitation of the salts. A light exhalation has been seen to come out of the body of a man, rest upon his head, and shine like a glow-worm without burning.

Earthquakes.

Even earthquakes are now supposed to be produced by electricity: what was once thought to proceed from subterranean vapours, is now attributed to the discharge of a cloud in a highly electrified state, either in its passage to another cloud or to the earth. Earthquakes are most frequent in dry and hot countries, and hot climates are more subject to lightning and other electrical meteors than those which are more remote from the equator. Another circumstance which seems to

confirm this opinion is, that the concussion of an earthquake is not followed by any noxious smell, which would probably take place if it proceeded from the explosion of vapour; and the atmosphere is found to be highly charged with electricity for some time previous to this dreadful calamity.

It has been observed by Lord Mahon, that damage may be done by lightning, not only by the main stroke of lateral explosion, but also by what his lordship calls the returning stroke; by which is meant the sudden and violent return of that part of the natural share of electricity gradually expelled from bodies within the range of the main stroke, by the additional passage of the electrical atmosphere discharged from thunder clouds.

Leyden Phial.

What is called the Leyden Phial is a glass jar coated inside and out with tin-foil, except about two inches on each side, from the top of the jar downwards, to prevent the connexion of the fluid between the inside and out when the glass is charged. The mouth of the jar is covered by a piece of wood, which receives a thick brass wire; the upper end of the wire has a brass knob fastened to it, and the lower end, which goes into the jar, has a small wire or brass chain fixed to it, that communicates with the bottom and sides, and serves as a conductor to charge the jar with electrical fluid.

Electric Battery.

In an Electric Battery, or a Combination of Jars, the accumulated fluid is capable of performing powerful

experiments ; but great care must be taken in using it, lest any person should chance to get into the electrical circuit, which would endanger his life if the battery were large. When the battery is used it is likewise highly necessary to use the electrometer, to ascertain the height of the charge. If a quire of paper be suspended by a string, and two ends of a conducting wire be brought near each side of it, and the circuit be complete, on discharging the battery, the electric fluid will pierce a hole through the paper without putting it in motion ; or, if a thick piece of glass be placed on an insulated stand, with a weight laid upon it, and the conducting wire of the machine be brought into contact with the ends of the glass, on discharging the battery part of the glass will be reduced to powder, or, if the glass be of tolerable thickness, it is sometimes coloured and shivered in a curious manner.

When the coated surface of the glass jars in the battery contains about thirty square feet, the fluid will melt brass wire of considerable thickness.

By means of the Electrical Battery metals may be suddenly fused and gases united ; but if fine metallic wire be made part of a powerful galvanic circle, it will be melted in an instant, and give out the most beautiful coruscations of light, of various colours, according to the nature of the metal employed. In like manner gold and silver leaf, when submitted to galvanic action, burn with the greatest splendour, and afford spectacles extremely beautiful. If a piece of charcoal, from hard wood, be inflamed by galvanism, the light produced seems to vie with that of the sun, being too intense for the eye to endure.

Electrical Machine.

As the excitation, which is produced by the hand with a rubber on a tube or plate of glass, is not only very laborious, but inadequate to the production of any material quantity of electrical fluid, machines have been constructed of various forms for this purpose, which are so generally known as to need little description: some of them are made with spherical glass electrics, some with cylinders, and others produce their effect by the revolution of a circular plate of glass between cushions or rubbers placed near the edge; but the cylindrical machine is the most common, and supposed to be the most useful.

Points.

I have in my queries stated, that any pointed metal touching the conductor now introduced into the navy, will draw off a proportion of the electric fluid, and that an explosion will take place where the point terminates, and I recommended globular trucks in place of spindles: it is therefore proper that I should explain.

It is a fact, confirmed by experiment, that points attached to any conducting body, either receive or deliver electrical fluid more freely than flat or round bodies. For this reason, the prime conductors of electrical machines are always furnished with points, to receive the fluid with more facility from the electrical atmosphere of the cylinder.

To shew the superior attraction of points—if the round knob of a brass conducting-rod be held near to the prime conductor when the machine is in motion, the electric spark will be seen darting towards it; but if a needle, or fine pointed conductor, be presented even at twice the distance of the knob, the sparks will instantly cease, and the fluid will be silently drawn off by the point; but when the point is withdrawn, the sparks will immediately recommence and fly towards the brass knob. If this experiment be performed in a dark room, (as Mr. Harris's experiment was,) a small globular spark appears at the end of the point when it is presented, which shows that the needle receives the fluid from the conductor. When the wire or needle is fixed towards the end of the prime conductor, on presenting a brass knob, or the finger, the fluid will pass off without any visible appearance; but the electric stream will produce a current like wind, which may be sensibly felt.

Chemical Definition of the Causes of Cohesion and Fluidity of Bodies.

When cohesive affinity between the particles of a body is strong, that body is solid: when this affinity is considerably diminished by heat, the body becomes fluid; but when the heat is very great, it destroys the cohesion altogether; the particles of the body then begin to repel each other, and thus are vapour and gas formed. It is, according to these facts, evident, why electric fluid melts, expands, and explodes metal. The

particles of this fluid are supposed to be so small, as to evade the scrutiny of the magnifying glass; it forces its way through every crevice or pore in metals, and performs the important office assigned it, in defiance of all our schemes to avert it. The force of cohesion increases in a substance, in proportion as its particles of matter, which cannot be decomposed, are brought nearer together; and it is the opinion of philosophers, that particles of all bodies are subject to the action of two opposite powers, repulsion and attraction; between which they remain in equilibrio. So long as the attractive force remains stronger, the body must continue in a state of solidity; but if, on the contrary, heat has so far removed those particles from each other, as to place them beyond the sphere of attraction, they lose the cohesion they before had with each other, and the body ceases to be solid.

By applying very much caloric to metallic and other bodies, they expand in all their dimensions, and the attraction of aggregation, or gathering into one mass, is so weakened thereby, that the particles of the body slide over each other, and are put in motion by the slightest impulse: on the contrary, the greatest number of liquid substances take a solid form by reduction of temperature. Thus water congeals, and forms ice. Even the gases show this disposition.

REVIEW OF, AND REMARKS ON,

MR. HARRIS'S

REPLY TO THE QUERIES,

To which the Reader is referred.

The order of Nature can receive no outrage without revolting at the violence of the attempt, nor will she warp to serve the private systems of men, nor accommodate herself to those modes of thinking, which are adopted without consulting her dictates. The grand chain of things lies straight before us; and though the human mind may be influenced by prejudice, or rendered tenacious through ambition, no inroads can be made. A deviation from Nature may be rendered plausible for a season; till, divested of those mists in which error conceals herself, she unveils the contradictions which await those, who, borne on the wings of presumption, dart into those regions where Nature never travels, and in which she refuses to become their guide.

To combat theory with fact and incident, must always be forcible, and sometimes conclusive; and when theory can be fairly confronted with such incidents as were intended to be invalidated, such facts and incidents must always be decisive of the point in debate. But when theory is established on the firm and immovable basis of solid and conclusive reasoning, fact itself must be presented fairly to the mind, to counterbalance the tendency of such reasoning.

The phenomena of appearances, are no proof of reality. Speciousness may dazzle the eye, but it cannot produce conviction in the philosophic mind, that

investigates with accuracy, and moves with slow but steady steps, from link to link, in the great chain of causes and effects.

I cannot doubt, notwithstanding the arguments of philosophers and others to the contrary, that electric matter has a variety of latent powers, which may for ever elude the researches of finite penetration, and in its physical origin, rest for ever in the Great Supreme.

We may, indeed, discover a variety of emanations, from whence we obtain the knowledge of its nature and action; but its utmost created proportions and power, at certain times and places, with the causes of its direful effects, when discharged in great quantities from the clouds, are concealed from the researches of philosophy, if not placed beyond the reach of all human comprehension.

The design of these pages, is, therefore, to make a natural inquiry into the probable utility, or dangerous tendency of fitting the fleet with fixed lightning conductors to their masts, and to point out the most distinguished properties and the action of electric fluid.

I had long thought, when revolving these abstruse subjects in my mind, that the term "electric fluid" was inapplicable to lightning, and that though thus applied as synonymous, it expressed a nameless something, varying in its properties; and to this, for want of our attaching more importance to the word *lightning*, and for want of a more expressive term, it is owing, that the minds of men are oppressed with difficulties in drawing that line of demarkation which distinguishes them from one another. This neglect in philosophic writings and experiments, has, in my humble opinion, led many into great errors, and has occasioned them improperly

to recommend conductors to be attached to houses and ships, by way of protection from the effects of lightning. But in discussing a matter like this, reason should be founded upon reflection, because it examines deeper than the surfaces of things. The present good is but a part of her province; it looks back on the past, anticipates the future, and forms its decision from the estimate of all.

I consider that the infinite divisibility which electric matter is capable of undergoing, cannot affect its permanent qualities; each particle is an equal partaker; and where those qualities are supposed to be annihilated, there the idea of matter can be no more. Metal conductors cannot annihilate it; they rather increase its quantity; and by concentrating it, add to its power. The hundreds of ropes of a ship are neither inviters nor promoters of the quantity of electric matter, but, on the contrary are exhausters of it, and evidently annihilate it as fast as it bursts upon them; and where there are no pointed metallic substances attached to a ship, for the reasons assigned, little fear need be entertained in lightning of ordinary occurrence. Among those properties which are necessary to the existence of electric matter, must be included its solidity, its magnitude, and figure; for without carrying in our mind those distinguishing properties, we can form no just conceptions of its power and wonderful effects.

All bodies, whether metallic or not, under every modification, must be formed of parts, and though united together, they are still porous. Now, then, according to this hypothesis, it is evident that these pores will admit fire or electric matter, that an assemblage of atoms will produce an increased magnitude, and that a

modification of parts will produce a change of figure. If any given portion of matter, though never so minute, can be conceived to exist, (though it have undergone every modification of which it is capable, in the endless series of divisibility,) still those properties must invariably adhere to its minutest parts, and are as applicable to an atom as to a globe. When electrical matter is sensible in the form of a spark, on an experimental conducting chain, created by the common electrifying machine, it is visible: from this we may draw some conclusion as to its quantity, when the clouds are charged with electric matter; and if it is a well known fact, that a sufficient quantity of matter is produced by the galvanic battery to diffuse the conducting chain, this will, in some degree, enable us to make a comparison with the matter thus acting upon the chain, and that discharged from the clouds acting upon conductors. In my humble opinion, the difference is so great, even in a moderate thunder storm, as to bear no comparison; and in a very severe storm, the fluid is at times in such vast quantities, as to expand, explode, and melt the three masts of the largest ship, were they all of metal, provided the whole force or quantity of matter from a fully charged cloud be drawn to them. All matter must extend in proportion to its magnitude; for if we subtract the idea of extension from any material substance, the ideas of solidity, magnitude, and figure, must perish with it. The idea of matter is also necessarily connected with that of space; not that space is an essential property of matter, or to be reckoned amongst its modes or accidents, but it is that pure expansion in which all substances must exist. If,

therefore, electric matter be drawn to a metal spindle, and its magnitude be greater than the pores of the metal will contain, (for from some unknown cause, the spindle may not melt,) that residue of the fluid will form in fire balls on the surface; but if any metal be within a certain distance from those balls, the matter will fly off to it; and notwithstanding the balls be gone, the metal first struck has a full charge of the fluid. But write who will, when and where they will, and whatever may be advanced, it is very certain, that our abstract ideas of the nature and action of electrical matter are very confused.

It is the opinion of philosophers, and much able argument has been advanced to prove the alleged fact, that the influence of electric matter can extend no farther than to surfaces,—that it is confined to the surface of all conductors, and never penetrates into the pores of metal. Surely fire penetrates into metals; and fire being a fluid, that metal into which it passes expands, and, melting, becomes a fluid also; and as lightning, or electric fluid acts upon metals as a strong fire does, this alone is a sufficient objection, if no other were adduced, to the placing conductors to pass down through the hull of a ship, and to the placing spindles in the higher parts of their mast.

Among other arguments advanced at the Plymouth Institution (in opposition to my stating, that such conductors, as those recently introduced into the navy, would expand, explode, and melt,) was the following.—If I am not much mistaken, it is nearly word for word; the person who advanced it having two small glass globes in his hands to illustrate the idea:

" If a ball (said he) shot from the mouth of a cannon, were to move onward with all its velocity to some destined object, it would produce no effect but in proportion as its surfaces were brought into contact with the surfaces of other bodies; and though, in the progress of its motion, it might rouse from a state of mere passiveness other portions of matter, and communicate to them a motion from its own impulse, yet, it must be evident, that those portions of matter, thus put in motion, could produce no effect but by bringing their surfaces into contact also with those of other bodies on which the effect was to be produced. Such, therefore, is the uniform manner in which all material bodies influence one another, and without which no effect whatever can be produced: and to suppose matter to produce effects where it is not, is to suppose it to extend itself beyond its own existence."

If this be meant to show that the electric fluid will not produce any body with which it does not come in contact, its propriety is admitted; but there is no analogy between the *propelled* action of a ball, and the *attractive* influence of bodies on the electric fluid: the one is direct and foreseen; the other depends upon the capacities and positions of the various conducting bodies to which the electric fluid may be drawn.

But I do not consider that this well known fact of the action of the ball's surfaces, &c. was a suitable comparison to my remark. Our faculties are suited to our stations in existence; but a boundary is fixed, beyond which we cannot pass. We discover the illimitable region above us possessed with all the wonderful phenomena of its nature, but the moment we attempt to seize it, it eludes our grasp

The mind, in investigating a subject which is so abstruse, may be oppressed with difficulties, which, to it, may be incapable of solution ; and, in cases like these, it is doubtless our greatest wisdom to close with that side where fewest difficulties and dangers are. An inability to comprehend too often creates argument; and if this inability be admitted as an argument against facts, by this almost every truth may be rejected; and those who affect to doubt the facts adduced, may often effectually enforce their point, and bring over many to their way of thinking, by maintaining their error, and bearing down all that may be advanced in opposition to their mistaken view of the question; and from a determined obstinacy not to admit of their error, may involve hundreds in the same, and condemn to oblivion, contempt, and cruel neglect, him, who has the honesty to say, "You are mistaken."

Should my little pinnace, which I have thus freighted and guarded, obtain her victory, and win her port, under such a heavy fire, it will not be amongst the least happy of my reminiscences, to look back upon my labours.

It is the province of reason, to examine abstract propositions; to ascertain the simple perceptions which are necessary to their existence; to travel through their various modes and relations; and to identify them by definition. By these rules I have endeavoured to be guided.

Let it be recollected by the reader,while going through the perusal of this Essay, that it contains nothing of private interest ; nothing of party spirit; nothing of secular advantage (with which authors are so often justly reproached). I must not rest here: the public indulgence will not, I am persuaded, be withheld from me, if

I go one step farther, by asking patronage for a volume in which arguments and facts are combined, for the purpose of arriving at truth; the immoveable basis, on which I rest my hopes. Whatever be the issue, I shall have this consolation—that I have done my best, and meant well.

Queries 1 & 2. The reply is not satisfactory, because, in the first place, holes must be made in the head of the mast or cap to receive the spindle; this will weaken the mast, and, by admitting moisture into the body of the wood, will cause it to rot. Secondly, the spindle will be surrounded by much metal; and as the conductor leading from it comes in contact with this metal, it will conduct the electric fluid out of its course, provided electric matter is confined to surfaces, which, according to Mr. H.'s own argument, and on the principle upon which the fleets are now fitted at Plymouth, is the case; and this is also the opinion of some philosophers.

Q. 3. The spindle having ten times more substance than the conductor or small strips of copper attached to it, will consequently, in my opinion, bear all that proportion more of electric fluid; and although the conductor may carry off some of it, yet enough will follow down the spindles to fire and splinter the masts.

I never witnessed what is stated in the Remark. An accident occurred from an overcharge of the electrical matter during an experiment; and what I expected

occurred, viz. the mast was shattered by the explosion; and although this must have been expected by every person present, at all conversant with the subject, and was so glaring as to call for an explanation from the chair, yet did it pass as an intended part of the exhibition.

Q. 4. How is the occurrence at Heckingham Poor-house to be accounted for? It was set on fire although armed with eight pointed conductors, and these conductors were constructed after the mode recommended by pholosophers?—Mr. H. states them not to be efficient, yet he introduces into the navy similar ones of very much less substance. This fact alone, which is fully stated in the Essay, proves that such conductors as Mr. Singer's *(who I consider to be the first inventor of fixed conductors to the masts of ships)* could not protect a ship.

The mere passage into the earth, he says, will not of itself prevent their action. Now I shall be glad if any person will explain the meaning intended to be conveyed by such a reply: does he intend for us to suppose that the fluid was conveyed by the conductor to the earth, and from thence rebounded to the sides of the house and fired it; or does he intend to say that the supporters of those conductors (iron rods) conveyed a proportion of the fluid to the house, and this caused the fire and broke holes in the walls?

Q. 5. Mr. H. states that there was no efficient conductor. As it often occurs that a ship is struck in several parts at the same moment, (and indeed this occurred at Heckingham Poor-house,) does then that gentleman intend to assert that any conductors would,

at such a time, or under such circumstances, protect a ship from the direful effects of lightning?

Q. 6. The man I considered to have been killed by suffocation, the lightning having instantaneously stopped respiration, and thrown off the atmospheric air usually pressing on all human bodies.

Q. 7. Notwithstanding this reply of Mr. H., he, in his lecture at the Plymouth Institution, darkened the room for the purpose of exhibiting the electric matter in the form of a spark upon his conductors, which was discernible to every spectator, as is always the case in these common experiments; and yet he declares that the spark is not visible on the surface of a continuous conductor. If this be a fact, then by that fact I am borne out in my opinion, that fixed metal spindles will splinter and fire the masts—that electrical matter fills the pores in metal, and sometimes acts upon it as water does upon a sponge; that it also occasions metal to expand, explode, and melt.

I never witnessed what is stated in the remark, and, in my humble opinion, it is not possible to perform the like. What I saw was some powder placed near to or touching the surface of the conductor, fitted after the manner of his Majesty's ship Java, and as the Minden and fleet are to be fitted; but the electrical matter not being sensible in the form of a spark upon the conductor at the moment it passed the powder, did not, therefore, cause it to ignite, but the instant the fluid reached the lower extreme of the conductor, placed over the touch-hole of a gun, it of course burnt the powder and fired the cannon. This experiment also bears me out in stating, that the spindles will splinter the masts, and that electric fluid is not always confined

to surfaces, but enters and fills the metal; and if the metal cannot bear the heat generally caused by an overcharge of the fluid, it must melt.

Q. 8. Here it is necessary to put the query, as it is said to be unintelligible. *Query.* What will prevent the electrical matter from being conducted throughout the whole of the lower parts of the ship, and under the powder magazines, by the bulge-water, through which it must pass before it can reach the bolts in the keelson, as the bolts and part of the conductor must always be covered and surrounded by such water?—Although this query is stated to be unintelligible, yet does Mr. H., in his experiment, strive hard to illustrate the fact of water being a conductor, and has proved by experiment that electric matter will, under some circumstances, become sensible in the form of a spark, and then pass away in the water.

Q. 9. What is to prevent the electric matter from being returned into the ship by the iron mooring-chains, should it, by the conductor, be conveyed through the bottom?—These chains are directly under the lower extreme of the conductor on the fore-mast, and they pass in the fourth foremost port-hole. This is the case with his Majesty's ship Java, and all the ships in ordinary at Plymouth, they not being moored by the head as formerly.

Mr. H., in his reply, says, when the electrical equilibrium is restored there is no farther action. This surely is not a reply to the query. The fact is, that electric fluid is conducted to these chains, and the vast quantity of copper upon the ship's bottom, by which it will become attracted; and as the chains lead

up into the ship, it is a question whether this matter may not return into the ship by these chains: but, for my part, I shall be glad to understand what will become of the electric fluid *when once it reaches the copper on the bottom.*

As respects the Remarks following the query, I need comment upon them but little, my reader will do all for me. I consider this gentleman, by his ingenuity, has evidently *discovered perpetual motion,* because, when the lightning is brought by his conductor to the chains and copper bottom, as it must keep moving, it may continue eternally to pass from one metal to another!

Q. 10. How is the continuity to be kept up when the top-gallant mast is hanging in the mast rope (G); at such times every plunge or roll the ship takes, keeps the mast in motion, and throws the conductor out of the line of continuity with the top-mast, and thus is the communication cut off—and it is not possible to prevent the mast from having such motion?

As some of my readers may not be conversant in this query, they will, by referring to the plate (p. 62.), observe, that there are three separate masts, one above another: the higher one, having the spindle placed in it, is called the top-gallant-mast, as will be seen in the plate, hanging in the mast rope, G. This mast, in severe weather, is lowered to ease the other masts; and when thus lowered it hangs suspended by the rope, and there are no means to prevent its being in motion. If it were possible to secure it, the pitching motion would break off the higher half, or royal pole.

Q. 11. What is to prevent the working of the mast from destroying parts of the conductor, it being short

short strips of copper nailed in a groove cut in the three masts, and placed vertically, as will be seen by the dotted line ?

Q. 12. How is the conductor to be placed to prevent the electric fluid from passing into the shieve-holes at each mast-head, there being six of these holes in the masts of every ship ; every hole is lined with copper, the shive or wheel, and the pin which secures it, being also of copper ?—The conductor is nailed to and touches parts of this metal. Now if the ring around the spindles, as fitted to the fleet, is sufficient to carry off the electric matter from the spindle, this fact will bear me out in supposing that the metal shieve-hole will carry off the matter brought to it by the conductor ; and if this be not the case, *then it is wrong to have these spindles.*

Q. 13. (marked 11. in the reply). To reply to this answer to my query defies me. What sense this gentleman intends to convey by naming an *uninsulated* conductor, I am not competent to say.

The query put is one of the most importance, because the conductor, in its passage down to the keelson, comes in contact with the many large hoops around the lower masts H, and passes very close to vast quantities of iron about the pumps, &c. &c. ; and if the ring around the spindle will carry off the lightning so must these hoops.

Q. 14. When the electric fluid is conveyed by the bolts in the keelson to the copper upon the ship's bottom, what will be the result ?

Mr. H., in reply to this, says, " it is the same as query 13 or 11, and the same answer replies to it." My

reader must at once be perplexed to reply to this query, because, until the experiment be tried, no one can form any just calculation of the result.

Q. 15. (marked 13 in Reply.) What will be the expence of completing the Navy with such conductors?

Every ship must be docked: the estimate I make is, taking one ship with another, £500 each: the whole sum, therefore, must depend upon the number of ships, every ten requiring the sum of £5000: 600 is the number of ships on the Navy List, so that £300,000 will be required. As to inconsistencies in my communications of the 20th of October and 11th December, I know not what is alluded to, if it be not my statement to the public Boards of the view I had of the matter. If that, and my Queries, be "descending to personal reflections," or "employing unhandsome insinuations," I am sorry for it; but as to my not having a different opinion from other persons, this is indeed "inconsistent." Who would admit the possibility of any fact, without some evidence to support the mind in its belief? I term the plan not original, because Mr. Singer appears to be the first person who proposed fixed conductors to the masts, and bolts through the keelson; and the idea of placing conductors round the hull was suggested by myself. Mr. H has placed them differently from Mr. Singer, but *neither of their plans could possibly be put into practice, even though they were efficient*. The plan I proposed to persons who would have conductors, was a globular metal top to the mast, which would not attract the lightning as a pointed conductor would, nor would it conduct *the electric* matter into the mast.

The *incomprehensible conductors* appear to be but

one, which is placed around the hull of the ship, terminating at a point under the head; this is an iron bar with a surface of six inches and one inch solid, placed as a protection to the hull as well as for a conductor; but this I proposed to be affixed to a new planned ship I built, having more beam than his Majesty's ships in general have, and no channels, with a view of boarding an enemy, without endangering the mast, by knocking away the channels, and to speedily disable him by knocking them away; at the same time to give strength to the ship in the most feeble parts, and more power to bear up against the pressure of her canvas. These channels act as so many levers placed to tear the ship to pieces, while my plan prevents this. Channels, I say, and I have paid much attention to this matter, are as useless as the fixed conductors, and prevent the builder from recollecting that beam is the grand master-piece. As every rope, when wet, is a conductor for lightning, and the principal ones leading outside of the ship, the proposed conductors in my ship might, from their magnitude and formation, protect the hull in some degree, provided the ropes brought the electric fluid down to the hull.

As to my stating that I came to the Institution to meet a jury collected to support Mr. H. under any circumstances, this was then, and is now, my decided opinion; to his statement of my libelling a set of gentlemen then present, who expressed their decided approbation, I can only say, I was invited to the lecture. When present, a general invitation was given for discussion or remark; and there were none of the many in the room, as far as I could discover, save the Naval Commander-in-Chief, and one gentleman who proved

that wet ropes were a protection to ships from lightning, who, in the smallest degree, condescended to admit one of my remarks as being worthy the notice of such an assemblage of philosophers, who, unfortunately for the community at large, confine within the walls of their institution all their discoveries, with a view, I suppose, at once to burst forth in splendour, disseminating vast and important discoveries, so modelled as to penetrate our minds with more rapidity than the lightning would pass through the fixed conductor, at once illuminating the whole universe, and proving that Johnny Bull's philosophers are the cleverest conjurors at this time under the sun!

Having, previously to the night of the Lecture, put Queries to Mr. Harris, through the medium of the public papers, as they remained unanswered, I considered it proper to beg that the President would permit me to read them, and direct that they should be replied to; but this request was contemptuously opposed, and I, therefore, felt as I presume every gentleman would, under similar circumstances, his patience being already almost exhausted by hearing whole volumes of quotatations read, from every author who had written with a mistaken view of the subject; and his ears stunned by the reiterated applause of an ill-judging audience. This was called a *Lecture!* The only lecture *I* discerned, was that addressed to myself. Perhaps I did not go to the Institution with an unbiassed mind: popularity is the Baal to which we all bow the knee, and I might be jealous of the "lecturer's" great renown. But if I envy him, I am quite sure I do not envy his admirers. Of books and authors, he spoke as naturally as I should of ships; but sentiments unaccompanied with practical

experience, I consider of little value. During this unparalelled, and till then unheard of performance, he introduced, together with hundreds of manuscript leaves, references to and quotations from Franklin, Singer, Priestly, and Cavallo; and Dr. Hunt's Natural Philosophy: but, with the ability I possess, and all the attention I could give, I was unable, with any degree of accuracy, to follow up one half the lecture, which, in my humble opinion, was only understood by the reader of it.

The ship under the influence of a thunderstorm, was H. M. ship, Cleopatra, commander the present Sir I. Pellew; as will be seen in my Queries.

"A continuous conductor," says Mr. H., "will not be melted," &c. &c.

All conductors are continuous, and therefore I am at a loss to know what is meant by this assertion. An efficient conductor, *if it were possible there could be such a thing*, might not be melted. Copper melts at 3807 deg. Far. Iron at 21837 ditto.

It is now for judges, superior to myself, to determine whether my remarks are "manifest contradictions," and my questions "unscientific." My Queries are original; while Mr. H. never gives his own opinion upon any question in his lecture that requires depth of metaphysical acumen: most of his ideas are adopted from others. He sneers at me because the printer inserted the word "literal" for "lateral;" yet, in the *very sentence* containing his sarcastic remark, there is a simimilar typographical blunder—as if to rebuke him for his illiberal conduct. Indeed, as a seaman, I attended little to style, and as for mistakes, they are pardonable; but how will that person, who caught at the error, account for his own? *he* has not spent the whole of his life-time in a profession, which precludes all scholastic erudition.

APPENDIX.

THE Appendix is not an unimportant part of my book; because it serves to shew the stated importance of the plan of fitting the navy with lightning conductors;—the sanguine views and arguments of those concerned;—gives the expences which would have attended completing the navy; not omitting what has been incurred in making experiments on the Water at Plymouth, and the cost of fitting His Majesty's ship Java, as also attending the exhibitions at and on the water before Somerset House.

Again, it may assist in furnishing sufficient matter of fact for argument, to decide the important question, and thereby put the affair at rest: *indeed it alone, speaks volumes,* and intimates what I ought in justice to state, yet leave it to the reader to infer.

To read only one side of the question; to hear but one party; clamorously to adopt every childish cavil, vague report, or scandalous falsehood, and industriously propagate them, as affording a sufficient confutation of all arguments, authorities, and testimonies opposed to them; is no evidence of a candid, liberal mind, or a sincere desire to arrive at the truth, and administer justice.

The doctrine advanced in support of the new theory,

which I oppose on the face of it, seems, to me, to be so preposterous and absurd, as to carry its own confutation: the basis, or general principle, is groundless.

Probably I do not possess the very desirable discrimination, that teaches when it is proper to speak, and when it is best to keep silent; but, since I am blamed for what some may call intemperate zeal, and censured for too much acrimony, and a want of politeness in putting my Queries,—I freely declare that, in my opinion, the complaisant humour of this age, with regard to diversity of opinions, should be checked in matters of this kind; because the practice, enjoined by it, of a placid acquiescence without conviction, is infinitely more pernicious than the most poignant asperity of language. In following up any object, where the cause of humanity may be served by preserving the lives of our fellow-creatures, it would be unpardonable to be silent, for the purpose of flattering the vanity of men, who, merely because they act in opposition to others, imagine that all the world admit that they have arrived at perfection; and who have the folly to suppose that nothing can be added to their own store of ideas; treating all who are capable, or think they are capable of instructing them, with contempt, severity, and neglect. Thus it would would appear that the decisions of some bodies are so arbitrary, as to overwhelm every thing which is not their own production, or that of some person they are desirous of serving, or by whose influ-ence they may themselves be served: consequently they oppose, with the most rancorous jealousy, whatever emanates from practical experience alone. Theories which are not plainly accounted for, ought, in justice, to be received with the greatest caution. What then

can be said, in extenuation of such conduct as the above, in behalf of those, who call themselves Gentlemen and unbiassed Men of Honour, and who outwardly profess to be guided only by justice and impartiality, and who live in what is termed "an enlightened age?"

ELECTRICAL EXPERIMENT.

[From the Dock Telegraph, Saturday, September 14, 1822.]

We last week noticed an invention by a gentleman of Plymouth, for conveying the electric fluid, by means of a copper conductor fixed in the masts, through the bottoms of ships. Instead of being ascribed to Mr. T. Harris, jun. as then stated, it should have been Mr. W. S. Harris. The experiment has taken place in the harbour, and completely succeeded, as will be seen by the following details.

It is not neccessary to quote the numerous instances of the tardy attention bestowed upon many important results obtained from natural and experimental philosophy; but it may now be sufficent to remark, that 70 years have elapsed since Dr. Franklin demonstrated the efficacy of metallic conductors in protecting buildings from the destructive effects of lightning. Although the application of conductors on land is generally judicious, and their advantages are admitted, yet on shipboard, where the effects of lightning are most to be dreaded, from the inflammability of the materials of which the ship and stores are usually composed, the introduction of electrical conductors has been lamentably neglected or injudiciously employed.—This indeed may in some measure be traced to the difficulty of placing

any fixed or continuous conductor in a situation so liable to change and motion as the mast and rigging of a ship; and consequently the only species of conductor that has been adopted is a chain, or long links of wire, one end of which is to be hoisted to the mast head, whilst the other passes over the side of the ship and communicates with the water; but independent of its defective construction, from its small dimensions, the inconvenience of being constantly hoisted, and its consequent liability to be injured are very obvious. This species of conductor is usually kept packed in a case, and only hoisted, on the approach of danger, which it may then be too late fully to avert. To remedy these inconveniences, Mr. Harris proposes to place in the back of the masts a slip of copper, which is to be continued to the interior or hole of the cap of each mast; consequently, coming in contact with the mast above, the continuity will be preserved without preventing the upper masts being lowered, The conductors of the lower mast are to be continued to the keel, and made to communicate with one or more copper bolts in contact with the exterior copper or the water. It must be clear therefore, that this arrangement preserves a permanent conductor so long as any part of the mast is continued, and as the masts of a ship may be considered as mere points when contrasted with a thunder cloud, thus armed they are virtually pointed conductors. To those acquainted with the action of points on charged electrics it will be obvious, and not too much to presume, that such masts will be highly efficacious in silently depriving a thunder-cloud of its charge, thereby giving to ships a degree of security of very considerable importance.

From these considerations Mr. Harris was induced to submit a model of a complete mast furnished with permanent conductors, to the inspection of the Hon. Navy Board, who expressed their decided approbation of the principle, and requested him to exemplify its efficiency by an experiment, which was carried into effect on Monday afternoon last, on board the Caledonia, in the presence of the Navy Board, Sir Alexander Cochrane, Commissioner Shield, several Captains in the Navy, and principal Officers of the Dock-yard, in the following manner:—The Louisa, cutter, having had a temporary mast and topmast fitted with a copper conductor, according to Mr. Harris's plan, was moored astern of the Caledonia and at the distance of 80 feet from the cutter a boat was stationed with a small brass howitzer. On the tiller head of the Caledonia were placed the electrical machine and an electrical jar, with the outer coating of which a line was connected, having a metallic wire woven in it: this line being carried out of the starboard window of the wardroom, terminated in an insulated pointed wire in the immediate vicinity of the touch-hole of the howitzer: a similar line was passed from the larboard window, which communicated with the mast-head of the cutter; and at the termination of the bolt through the keel, a chain was attached, connected with another insulated pointed wire in the boat placed in the vicinity of the touch-hole—the space between the insulated point being the only interval in a circut of 300 feet, from the positive to the negative side of the jar. Some gunpowder being placed in contact with the conductor in the cutter, and the priming in the interval of the insulated points, the jar was charged, and the line attached to the mast-head of the cutter

being brought into contact with the positive or inside of the jar, a discharge of electric matter followed, which was passed by the line to the mast head, and by the conductor through the powder to the chain in the water, by which it was conveyed to the interrupted communication in the boat, where it passed in the form of a spark, and discharging the howitzer, returned to the negative or outside of the jar by the line leading into the starboard window, thereby demonstrating that a quantity of electric matter had been passed by the conductor through the powder (without igniting it) in contact with the mast of the cutter, sufficient to discharge the howitzer. Mr. Harris then detached the communication between the keel of the cutter and the positive wire in the boat, leaving that wire to communicate with the water only, but this interruption did not impede or divert the charge, as the discharge of the howitzer was effected with equal success as in the first instance, the water forming the only conductor from the cutter to the boat. In order to demonstrate that a trifling fracture or interruption in the conductor would not be important, it was cut through with a saw, but this produced no material injury to its conducting power.

These trials, carried on under the disadvantages of unfavourable weather, could not fail of convincing all present of its efficacy, and called forth the decided approbation of the Navy Board in particular, which was evinced by Sir T. B. Martin requesting Mr. Harris to superintend the equipment of the masts of the Minden, 74, and Java, frigate, preparatory to its general introduction into the navy.

ON THE LATE ELECTRICAL EXPERIMENT.

To the Editor of the Dock Telegraph.

SIR,

During the years 1812 and 1813, I was in intimate correspondence with Mr. Marrat, the author of a well known Treatise on Mechanics, and also of an interesting work on the Antiquities of Lincolnshire: and with the view supporting a periodical work named the Enquirer, then conducted by Mr. M. I was in the habit of collecting philosophical articles from other periodical works, and composing original scientific papers for its use. One article, obtained from the Christian Observer for July, 1813, on the subject of iron masts, was sent by me to Mr. Marrat, and published by him in the third volume of the Enquirer. The following is an extract from it:—"Ships furnished with iron masts will not, like others, be exposed to the risk of receiving damage from lightning, the iron mast being itself an excellent conductor: by using an *iron bolt from the bottom of the mast through the keelson and keel, the electric matter will be conducted through the bottom of the ship into the water, without injury to the ship.*"—Enquirer, vol. 3. page 60, 1813.—In the volume of the Enquirer above alluded to, *the source from which I obtained the article in question was distinctly mentioned.* How far its object is the same with the primary principle of experiment alluded to in your last paper, I leave your readers to judge.

I remain Sir,

Your humble Servant,

GEORGE HARVEY.

Plymouth, Sept. 19th, 1822.

To the Editor of the Telegraph & Chronicle.

What is that word Honour?—Air.
Will it not live with the Living?—No.
Why?—Detraction will not suffer it.

Sir,

Observing in your paper of last Saturday what I consider likely to mislead the public, respecting the primary object of the late electrical experiment, as well as to throw an illiberal reflection on my efforts, I feel it necessary, for the purpose of preventing any further misunderstanding, to lay before your readers the following considerations respecting it.

Having long regretted the extensive injury which has occurred at sea, from the effects of atmospheric electricity, I began to reflect how the continuous conductors employed by the celebrated Franklin to protect stationary elevations, could be made equally applicable to the masts of ships, and be applied in such a manner that the elongation and shortening of the masts might at all times be possible without interfering with the continuity of the conductor, so that the fixed and sliding masts should under all circumstances have permanent conductors in action, thereby protecting the ship, her cargo, and crew. This point, so long desired by many scientific persons, more particularly by those engaged in electrical pursuits, is obtained by inserting slips of copper along the different succession of masts so as to form part of them; and further by providing an adequate connection in the caps through which they slide, by means of a lining of the same metal. Having contrived this, it was desirable to form a similar com-

munication with the water in the most direct way; and I therefore chose the strait line through the keel, in preference to many others. This application of Dr. Franklin's conductors I first produced about two years since, before one of the most valuable societies in this part of the country, the Plymouth Institution; and accompanied it with several original experiments to demonstrate its utility. Now the writer of the letter in your last paper was present with above one hundred others; and notwithstanding a long discussion ensued on its merits, not a word from any one was advanced respecting the views of those ingenious men who had proposed to construct masts of iron, the circumstance not then being generally known or understood. I was therefore, quite ignorant of such a contrivance; so that whatever coincidence occurred between that part of my application which relates to the metallic communication through the keel, and the *precaution* taken by the proposers of iron masts, still the whole scheme was *original* as far as concerned me; and I feel obliged to the writer of the letter before alluded to, for taking such pains to shew that my ideas concur with those of intelligent persons—a circumstance highly flattering to me, and which will ever give me considerable gratification. Your impartial readers will, however, perceive on reflection, a wide difference between the causes in which the metallic connection with the water originated: with the proposer of an iron mast, who certainly never contrived it to *protect his ship from lightning*, the bolt through the keel was a matter of absolute necessity; with me it was a matter of choice: and it is probable the inventor of an iron mast would have avoided the circumstance altogether, could he have found a means: but without it the

ship was exposed to the most fatal mischief. If its conducting properties had formed any portion of the original design, there would naturally have been some provision for the top-masts, and the sliding masts above, which not being (as far as I can learn) also of iron, were placed in a very dangerous predicament; it being a well-known electrical fact, that the most violent effects on imperfect conducting substances are produced in an interrupted circuit: now this is precisely the situation of the higher masts, which are supposed to occupy a space between the vast body of the thunder-cloud above, and the mast of iron below. The rigging and sails on those masts would therefore, in all probability, be set on fire, and so far endanger the ship; such a protection, therefore, as an iron lower-mast afforded, was but an *imperfect one* at least, and consequently formed no portion whatever of the original invention.—Now in the application of fixed conductors to *masts of wood*, proposed by me, the direction of the metallic line was a matter of choice; and if it be a desideratum in philosophy, to bring about the most important ends by the simplest means, I think it will be found to obtain here, there being a metallic connection with the water, from the vane and spindle at the mast-head downward, applied to moveable masts, an application *never before attempted*. The copper bolts which I propose to use as conductors through the keel, did not therefore arise out of *sheer necessity*, but were *suggested by that chain of reasoning*, which led to the application of the conductor at first.

These explanations have been extended rather further than I originally intended, from a desire that such of your readers as may not have hitherto considered the question, may now perceive on what ground it stands,

and likewise for the benefit of the writer of the letter in your last paper on this subject,who, I suppose, principally from not being so well acquainted with electrical investigations, as with many other branches of science, has strangely mixed up the ingenious contrivance of *masts of iron,* with an application of conductors for lightning to *masts of wood;* and what is still more extraordinary, (every possible allowance being made for such a circumstance) has assumed in plain terms that the primary object of the experiment was not to shew the practical application of the plan I have been detailing, but to demonstrate a well-known electrical fact—namely, *that a metallic bolt* was a conductor of electricity, concluding his observations by inviting the judgment of his readers to determine how far this which he is pleased to call "the primary principle," is the same with the *object* of my experiment.*

I think, Sir, if he had at all reflected on that very *simple* question at an early period, a letter so very foreign to the real merit of the case would never have occupied a place in your journal.

I am, Sir,

Your very obedient Servant,

WILLIAM SNOW HARRIS.

Plymouth, Sept 26, 1822.

* The following is an extract from the letter alluded to:—"By using an *iron bolt* from the bottom of the mast (speaking of an iron mast), through the keelson and keel, the electric matter will be conducted through the bottom of the ship into the water.

"How far its object is the same with the *primary principle* of the experiment alluded to in your last paper, I leave your readers to *judge.*"

To the Editor of the Telegraph and Chronicle.

Sir,

Actuated by the purest motives—by that love for philosophical justice which should, at all times, direct the conduct of those who are engaged in scientific pursuits, I was induced, in a former number of your journal, to introduce to the notice of your readers, a fact which seemed to me to throw some light on the history of a very useful invention. This circumstance, however, has excited the warm indignation of a correspondent; and he has rather inconsiderately charged me with an intention of undervaluing his labours, and of endeavouring to deprive him of that portion of applause, which the ultimate judgment of the public might award to him.

Every man has a right to an opinion; and the value of that opinion must depend on the nature of the evidence with which he happens to be furnished. I mean not to provoke an angry and unbecoming controversy, when I state my conviction that, according to the evidence which I possess at the present moment, the plan your correspondent has proposed, is not original. That it is useful, and most probably will be the means of doing much good, and that he deserves praise for having called the public attention to the subject, I readily and most cheerfully admit. But while I am thus free in offering my suffrage in its favour, I cannot feel insensible to the claims of those labourers in science, who have preceded him in the inquiry. The idea of transmitting the electric fluid through the keel into the water, appeared to me, when I read it in the *Christian*

Observer for 1813, as a bold and magnificent thought; and although nearly ten years have elapsed since the circumstance took place, the impression it made on my mind has not yet lost its force; and it was this circumstance, more perhaps than any other, which induced me to send the article alluded to in my former communication to Mr. Marrat, to give it a still wider publicity, by means of his journal. Your correspondent observes I was present at his lecture. It is true: but a lecture-room is not the place to state all the recollections that flash across the mind. The first time, however, that your correspondent called at my house, after the delivery of his paper, I pointed out the article to him.

Having thus stated, candidly, the grounds on which I have been induced to form my opinion, that the part of your correspondent's plan, which relates to the transmission of the electric fluid through the keel into the water, was known prior to the year 1820, I will, in the next place, furnish you with the extract, which has induced me to come to a similar conclusion with respect to the "fixed conductors;" and in doing this, I wish it to be clearly understood, that I am actuated by no hostile feeling, but by principles and motives entirely the reverse.

Mr. Singer, at pages 225 and 226 of his *Treatise on Electricity*, has the following remarks:—"Conductors for ships have been made of chains, (which are highly improper,) and ot copper wires, which are easily attached; but they are with equal ease detached; and I have been informed by several captains, that many ships furnished with such conductors, keep them in an inactive state, packed up below, during long and hazardous voyages. *For this reason it would be better that fixed*

conductors should be used; they might, I should conceive, be attached to the mast; and where motion is required, an interruption might be made in the flexible conductor, and its parts be connected together by a length of spiral wire, *which would be at once perfectly continuous, and sufficiently flexible to yield to every necessary movement.*"

The same extract may be seen in the review of Singer's work, in the 47th volume of the *Philosophical Magazine,* page 136.

I now take leave of your readers with every sentiment of respect, and of your correspondent, without the smallest feeling of an angry kind,—wishing him success as the promoter of a useful plan; and at the the same time entertaining every just and proper regard for the labours of those who have preceded him in the inquiry.

I remain, Sir,

Your obedient servant,

GEORGE HARVEY.

Plymouth, Oct. 4, 1822.

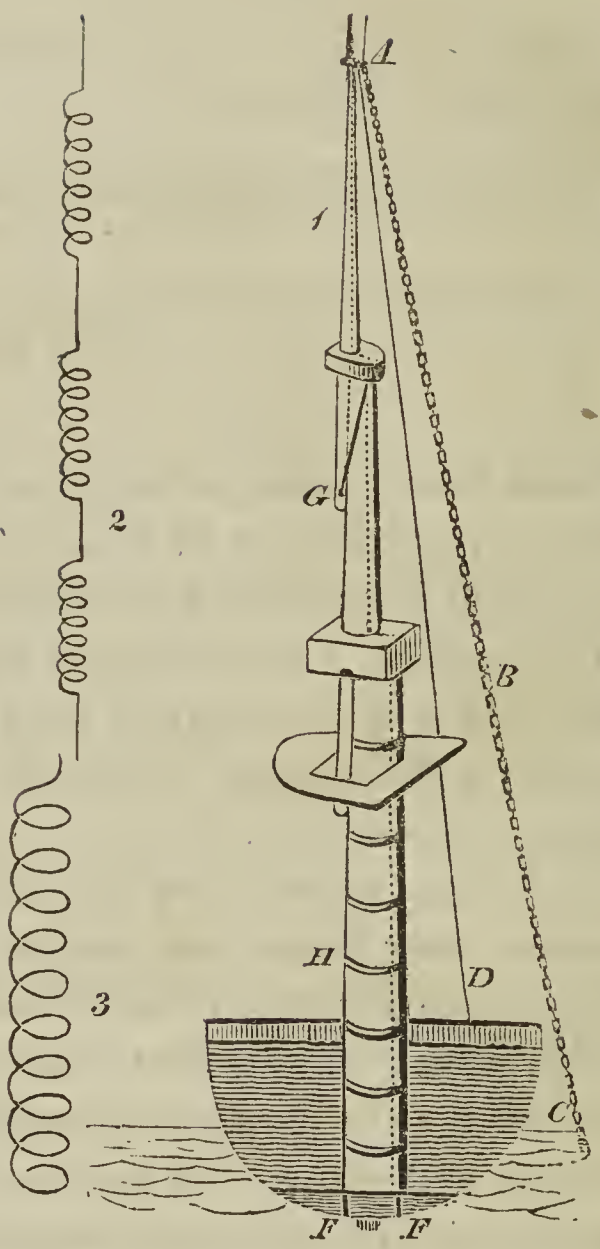
To the Editor of the Telegraph and Chronicle

"Yours is justice business, you say."
JOHN BULL.

SIR,

A second letter having been published in your Journal, respecting my application of conductors to the masts of ships, in which the writer has manifestly shifted his ground, and made a new attempt to detract from the contrivance, I feel it necessary to shew the public that his reasoning in the presence instance is as equally unwarrantable as in the former.

The passage he has quoted from Mr. Singer's work on electricity was *chosen by me*, and read in my lecture on this subject at the Plymouth Institution two years since, (at which your correspondent allows himself to have been present) for the purpose of shewing that the author, in common with many other persons, considered the present application of conductors to ships as objectionable, but that no efficient plan had been proposed as a substitute. It is almost needless to remark, that the suggestion of that excellent philosopher respecting inflexible conductors, joined by spiral wires, has nothing whatever in common with the contrivance I have demonstrated, by actual experiment, to be practicable, and I have certainly reason to complain that parts of this quotation have been particularly marked in *Italics*, by your correspondent, thereby *unfairly representing* my efforts, and conveying a wrong impression respecting my contrivance to the public.



A Exhibits the spindle of the conductor now in use.
B The conductor, a copper chain.
C The conductor dangling in the sea.
D The haulyard, or rope, by which the conductor, which is very light, is hoisted or pulled up with ease, by one man.
F F Situation of the bolts driven through the keelson, for the purpose of conducting the lightning into the sea.
G The mast-rope.
H The iron hoops.

A diagram of a ship's mast, with the top-gallant mast partially struck, is seen under *Fig.* 1, in which the conductor employed by me, and represented by the dotted lines, is so managed, as to be in every possible

respect a part of the mast itself, and is seen passing from the spindle at the mast-head, downward to the copper lining in the caps, through which the sliding masts pass, unto its metallic connections with the water at the keel. If this should meet the attention of persons generally, more particularly those acquainted with nautical subjects, they will be immediately struck with its dissimilarity to that conductor represented under *Fig.* 2, which is, as described by Mr. Singer, an inflexible conductor in parts, connected by spiral wires, the spiral itself being represented by *Fig.* 3. This, according to his suggestion, is to be attached to the masts: why the present chains are attached to the masts, but it is in no way directed to be applied so as to form a portion of them, that being from the very nature of the suggestion, *impossible.* In what way it is even to be attached Mr. Singer does not explain. Feeling myself at a loss on this point, having carefully tried with the model of a mast in various ways, I am unable to convey any idea respecting it by means of a diagram, which otherwise would have been done. It was with him, evidently, a conjecture, for had he directed his able mind to naval pursuits, he would have found it in every way inconsistent with the construction of the masts of ships. Now your correspondent would have it supposed that *he is aware* of the mode of its application, although it appears this circumstance, in common with his communication respecting iron masts, had, at the time he heard it stated, escaped his recollection, notwithstanding that made a ten years' impression on him. I cannot help thinking it rather extraordinary this impression should, in a following sentence, be classed with those recollections which *flash across the mind,* and view as still

more extraordinary that a Lecture-room is not considered a *place* for such recollections, although the actual experiment which, according to him, was identical with "the bold and magnificent thought" itself of conducting the lightning through the keel, had then *been performed in his presence and was under discussion.** I may here remark, that the passage from the *Christian Observer* was not read before me until several months had elapsed, and not then with any reference to my contrivance, but as connected with iron masts. The metallic bolt, he states, was known prior to the year 1820, but surely he *cannot* be ignorant that it was known in the time of Franklin, 70 years ago. Your readers will perceive that I lay no sort of claim to the first invention of conductors, but simply to their application in this particular instance, which application is totally distinct from any thing ever before proposed or attempted; that, consequently, I am, in *this sense*, under no obligations to Mr. Singer or any one else, much less have I any connection with the communication respecting iron masts, by your correspondent, ten years since, which he himself allows was not read to me until after the whole scheme had been made public, at which time I was ignorant that iron masts were ever in contemplation.

It is in this way, Sir, that many proposers of the most

* The following is the passage alluded to: — "The idea of transmitting the electric fluid into the water appeared to me, when I read it in the *Christian Observer* for 1813, as a bold and magnificent thought, and although nearly ten years have elapsed since the circumstance took place, the impression it made on my mind has not yet lost its force."

* * * * * * * *

"Your correspondent observes — 'I was present at his lecture, it is true, but a lecture-room is not a place to state all the recollections which flash across the mind.'"

useful applications have been attacked "in an unbecoming manner," (to use the language of your correspondent) by persons whose duty it is, from the situations in life which they occupy, as well as from their professing a love of science and philosophical justice, to shew that liberality to others which they themselves so reasonably expect. If the elements of my contrivance were also *known* to your correspondent, as well as *the plan itself* (of which he says I am only the promoter) why did *he* not bring it before the public iong since. Ten years is a serious lapse of time to allow a plan calculated to save lives and property to lie inactive. Sad specimen of philosophical justice, this ! Why it is really, to use the words of *Job Thornberry,* in the celebrated comedy of *John Bull,* when the public come to "deal largely" with him in that article, fairly "shutting the shop windows."

It is unnecessary for me to offer any further explanation. I feel satisfied to leave your correspondent's motives (which no one can possibly mistake) to their own fate, and my claims in the hands of dispassionate enquirers, who while they are wisely jealous of any undue interference with the merits of others, are capable of appreciating the disposition of one who scorns both *open* and *concealed* detraction, and the still more despicable meanness of submitting to the public the labours of other men as his own.

I am, Sir,
Your very obedient Servant,
WILLIAM SNOW HARRIS.

Plymouth, Oct. 9, 1822.

To the Editor of the Telegraph & Chronicle.

Sir,

Two letters have appeared in the Dock Telegraph, wherein Mr. G. Harvey states his conviction, that Mr. Harris's plan for preserving ships at sea from the destructive effects of lightning is not original, I hope your correspondent will not deem it a bad compliment if I express my surprize that his opinion is not better supported, and will allow me to explain what appears to me to be the difference between Mr. Harris's plan, and the two which he has produced. This is not altogether a useles disquisition:—honour should be given where honour is due. With generous minds it is a noble stimulus to exertion; and praise should always be awarded justly, and given freely.

That "every man has a right to an opinion" on such a subject, I am disposed to question; and still more that " the value of the opinion must depend on the nature of " the evidence with which he *happens* to be furnished." It may be doubted whether any man " has a right to an opinion;" or, at all events, to promulgate an opinion that may wound the feelings, or be detrimental to the reputation of another, unless he has taken care to collect *all* the evidence which the case admits of. And if he has, it by no means follows that " the value of the " opinion, must depend on the nature of the evidence: " it is possible for the evidence to be complete, and the opinion false. The value of the opinion, therefore, will depend as much upon the soundness of the judgement and the candour of the party, as upon

the nature of the evidence. From the tone of Mr. Harris's reply, I presume he thinks he has occasion to complain that the "evidence" has not been fairly estimated; but this I leave to the decision of your readers: my business is with the question.

To state the matter fairly, Mr. Harris claims the merit of an INVENTION by which ships may be protected from the effects of lightning, when at sea. Mr. Harvey admits the utility of the plan, and that "Mr. Harris deserves praise for having called the public attention to the subject," but states "his conviction that, according to the evidence which he possesses at the present moment, the plan is not original."

I presume your readers know that Mr. Harris's invention consists in carrying "a fixed conductor" from the mast head, through the keel, to the water. To prove that the invention is not his, Mr. Harvey first quotes a passage from the 3d vol. of the Enquirer, p. 60, 1813: "Ships furnished with iron masts will not, like others, be exposed to the risk of receiving damage from lightning, the iron mast being itself an excellent conductor: by using an *iron bolt from the bottom of the mast, through the keelson and keel, the electric matter will be conducted through the bottom of the ship into the water without injury to the ship.*" And in his second letter, another passage, from Mr. Singer's Elements of Electricity, p. 225-6. 1814: "Conductors for Ships have been made of chains, (which are highly improper,) and of copper wires, which are easily attached; but they are with equal ease detached: and I have been informed by several Captains, that many ships furnished with such conductors, keep them in inactive state, packed up below, during long and hazardous voyages. *For this*

reason it would be better that fixed conductors should be used; they might, I should conceive, be attached to the mast: and where motion is required, an interruption might be made in the inflexible conductor, and its parts be connected together by a length of spiral wire, *which would be at once perfectly continuous, and sufficiently flexible to yield to every necessary movement.*"

Mr. Harris has not pretended to the invention of a conductor: his invention is the APPLICATION OF THE CONDUCTOR to the peculiar arrangements of a ship's mast; and it does not appear to me that his mode of application has been at all anticipated.

I scarcely need say that the iron mast was not originally proposed as a conductor of electricity; but from the known readiness with which it exercises this power, it was indispensable to provide a means of communication between it and the water, as the striking of the mast by lightning would be instantly followed by the destruction of the vessel. The assertion with which the first quotation opens, "that ships, &c." is incorrect; for, as only the lower mast is of iron, the top and sliding masts, being still of wood, would be in greater danger than ever, as they would hold nearly the same relation between the cloud and the iron (particularly if the mast be surmounted by a metallic vane), as the keel, without the bolt, would between the iron and the sea. By not providing against casualties from this source, the proposer of the iron mast cannot share the merit of Mr. Harris's invention.

Let us now examine the justice of the claim made in behalf of Mr. Singer. It must be admitted that he perceived the necessity for a "fixed conductor;" but it must not be denied that he likewise perceived the

difficulty of accommodating it to every necessary movement. "He conceived it might be attached to the mast, and that where motion was required, an interruption should be made in the inflexible conductor, and its parts be connected together by a length of spiral wire." We are not told how these spirals are to be used; but as a spiral would be required between the top of the lower mast and the heel of the top-gallant mast, between the cap of the top-mast and the foot of the royal, and so on, until it arrived at the pole supporting the vane (motion being required at all these points), it is evident that such a series of wires, if not altogether inapplicable, would be exposed to many objections: they would be in danger of being entangled in the rigging, and, like the "copper wire," of being broken or detached by it. In gales of wind, too, the sliding masts are not unfrequently taken down upon deck, which makes it necessary that the spirals should not be "fixed."

To use Mr. Singer's own words, "the conductor should not only be perfectly continuous, but sufficiently '*flexible*' to yield to every necessary motion;" from which it is plain that he thought it could only be effected by means of a flexible wire, which could not be imbedded in the mast like Mr. Harris's slips of copper, and thereby be preserved from having its continuity disturbed. Now the excellence of Mr. Harris's invention is, that it requires no "*flexibility*," nor is it exposed to any of the evils which that flexibility entails; *it is permanently fixed throughout its whole extent; is perfectly continuous from the keel to the mast-head; and admits not only of every possible motion of one portion of the mast upon another, but of any part of the mast being removed*

either by accident or design, without having its continuity interrupted for an instant.

I have detained you a long while, not having had leisure to make my letter shorter. Notwithstanding, I think I have proved that the plan by which *a permanent, continuous, and fixed conductor of electricity* is rendered applicable to all the possibly varying circumstances of a ship's mast, is Mr. Harris's own; and I trust that your correspondent (whose name I have too frequently used, and for which I hope he will pardon me) will, on a review of the evidence, be of the same opinion.

I am, Sir,

Your obedient servant,

J. C. COOKWORTHY.

Frankfort Place, Plymouth,
October 11, 1822.

P. S.—It is but justice to Mr. Harris to add, that in the lecture which announced his plan to the Plymouth Institution, he read the very passage quoted by Mr. Harvey, so little was he aware of borrowing from that source.

To the Editor of the Telegraph and Chronicle.

Dock, *Oct.* 25, 1822.

Sir,

As much has been said of late in your paper on the subject of lightning conductors, and as it is of the utmost importance to the navy of our country to have this subject fully and candidly discussed, I beg you will give a place in your columns to the following observations

and queries, part of which occurred to me, many years since. Though in all probability I shall be a partaker of the disadvantages or advantages of Mr. Harris's conductor, I shall be much obliged by his replying to the following queries: —

How is the place of the spindle at the mast-head to be substituted, when the top-gallant mast is on deck, which is always the case in bad weather, and often when the lightning is most severe and dangerous?

How the iron on the cap is to be placed, to prevent its power of attracting the electric matter led by the conductor immediately in contact with it, particularly so when the top-gallant mast is on deck, the cap must then be the point of attraction?

How the spindle, (in the truck,) which passes at least six inches into the body of the mast, is to be fitted, to prevent the electric matter from following it down, and splintering the mast?

How is it to be accounted for that a house should be set on fire, notwithstanding it was armed with eight pointed conductors, one placed to each chimney, reaching four feet above the top of the chimney, and down into the earth?

How a ship, with a spindle similar to Mr. Harris's in the main truck, should be struck by the same flash of lightning in the lower mast, two-thirds up the deck, and bulk-heads below destroyed; the electric matter at the same moment entering the starboard side, destroying the plank and every thing in its way?

How a man on board the Salvador here should be killed by lightning, when advancing up the rigging, the spindle in the mast-head far above him, no injury being done to the masts, rigging, or hull?

The conductors now in use in the navy are hoisted up to the mast-head, the spindle being six or eight inches above the truck, and not connected with the mast in any way, naturally conducts the electric matter clear of the mast, yards, rigging, and hull, the whole of the conductor is outside the rigging (and touches the water,) which prevents its being injured by any means.

As I am in possession of many statements of the effects of lightning, and have much to communicate on this subject, I shall continue to give you some extracts, should this meet a place in your columns.

I am, Sir,
Your obedient Servant,
WILLIAM PRINGLE GREEN,
Lieut. R. N.

MR. HARRIS'S LIGHTNING CONDUCTORS.

[From the Plymouth Telegraph.]

Every useful improvement, made in any department of science, gives pleasure to the philosophical and benevolent mind; and in proportion as its effects are operative, either in removing the evils, or contributing to the enjoyment of life, our admiration is excited and our respect for its author heightened. The recent invention of fixed conductors to ships, from the terrific evil from which they are proposed to rescue thousands of our brave defenders, and from the certainty of their effects, ranks high amongst the modern improvements in science. Its operations are not confined by any local circumstances even to our own country, but will,

we trust, in the philanthropic spirit of true philosophy, be so extensive as the evil with which it has to concontend. The application of conductors, to guard ships from the effects of lightning, was proposed soon after the application to buildings on land; but from scientific men being generally but little acquainted with the construction of ships, the methods proposed have been found inadequate to the circumstances of the case. The conductors generally supplied to British ships of war have been moveable chains, which it was intended should be continued from the top-gallant-mast head, down the back-stay, over the channels, into the water. The trouble and difficulty of fixing these conductors have generally prevented their use; and most serious injuries from lightning have been the consequence, in numerous instances, of the want of the necessary means of security.

Mr. Singer, and several other electricians have perceived the necessity of *fixed* conductors instead of *moveable;* but the application of them, so that a continuity should always be kept up, from the highest point of the masts to the water when the upper masts were lowered, was a difficulty which they could not overcome. The diversity of talents so evident in the progress of every department of science, is admirably adapted for the benefit of the world. It is seldom that ideas are conceived, carried into execution, and brought to perfection by the same person; and very often, without particular modifications and collateral inventions, the world would not be benefited by the profound researches and brilliant discoveries of philosophy.

This is precisely the state of the case of the conductors to ships' masts. While buildings on land are

defended, ships would have remained exposed to the greater danger of their situation; and even the great discoveries of Franklin might have been but of little use to ships, had not Mr Harris, by his invention of the application of fixed conductors to their masts, conferred a benefit on mankind, at which every feeling mind must rejoice.

The invention of Mr. Harris is a fixed apparatus which will keep up a continuous line of conductors, equally well when the upper masts are lowered, as when raised. Strips of copper sheet in two layers are let into the after part of the masts, which are connected by means of copper rods, because of the greater extent of surface obtained; as the electric fluid is found to be transmitted along the surfaces of conductors, which, therefore, require only sufficient thickness to prevent fusion. The extent of conducting surface is given greater than the best electricians. A metal rod is fixed on the truck, which may be re-fixed at the head of the top-mast, when the top-gallant mast is struck, if thought necessary. The continuity is kept up from the heel of the lower masts into the water, by copper bolts driven through the keelson, and meeting horizontal bolts driven transversely through the keel; this disposition being adapted to prevent the bolts from passing through the false keel. To prevent the possibility of a discontinuity when the top-mast being considerably less than the hole in the cap, having a metal drop attached to it by a hinge, which allows it always to fall against the copper in the top-mast.*

* From the obscure construction of this latter sentence, it is impossible to understand how the continuity is rendered complete. The above, however, is a faithful extract from the panegyric published in the Nautical Register.—W. P. G.

That this mode of fixing conductors to ships' masts will be attended with great benefit, there can be but little doubt; and that the number of accidents occasioned by lightning at sea, will bear a very small proportion to those which we at present lament.

The question no longer is, whether the principle of conductors be good, but whether their effectual application can be ensured; and this Mr. Harris appears to have done with such an acquaintance with the objections that have been, and may be brought against it, that it cannot be doubted but that the invention will be established on the most solid and satisfactory grounds.

MR. HARRIS'S NEW PLAN FOR LIGHTNING CONDUCTORS TO SHIPS.

[From The Magnet; or, Plymouth Monthly Magazine.]

We lay before our readers the particulars of an application of great importance to the nautical world, which reflects the highest credit on the inventor, and has proved so satisfactory to the Commissioners of the Navy, as to induce them to ascertain its efficacy by experiment, in order to its general adoption in his Majesty's ships. Mr. W. S. Harris, of Plymouth, first gave publicity to his invention in a lecture on the subject of Atmospheric Electricity, delivered at the Plymouth Institution, on the 21st of December, 1820, when, with a model of a ship's mast, furnished with a conductor on his plan, he performed the highly gratifying experiment of passing the electric matter through a combination of the most inflammable gases, oxygen, and hydrogen, which surrounded it, without igniting them.

It appears that in the course of Mr. Harris's investigations into the nature of electric phenomena, he was struck with the circumstance, that although nearly 70 years have elapsed since the important discovery of Franklin, and the consequent application of pointed metallic conductors to high buildings, yet no efficient method has hitherto been adopted for the protection of ships, which are continually exposed under the worst circumstances to the most fatal mischief. By a simple method, Mr. Harris has converted the most obvious cause of danger—the vessels' masts, into an effectual means of protection, so as to render the ship and crew secure against any electrical accumulation whatever.

The manner in which conductors are applied to high buildings is known to the most common observer, being usually a succession of continuous iron rods; but the same method has been deemed inapplicable to the masts of ships, which, being so differently circumstanced from stationary elevations, are subject to the necessity of frequent elongation and shortening; the conductors now in use are therefore usually made of chains, or long copper links, which are hoisted up by the signal halliards to the mast-head, and allowed to dangle over the side in the water. These are very objectionable, as it must be sufficiently obvious they are ill calculated for the hazardous and variable situations to which ships are exposed whilst under sail or otherwise; and if broken or detached, will, under some circumstances, conduct the lightning into the vessel: nor is the continuity perfect, in consequence of the numerous links which allow the electric matter to produce mischief at the points of junction. Those conductors are kept packed in boxes, and are frequently,

in some cases, set up as a preventive after the injury has been sustained; in others are never used at all.

Mr. Harris's invention provides a remedy for those inconveniences, by producing *permanency without impeding motion and perfect continuity*. A copper slip is applied in such a way as to form a portion of the different succession of masts: it begins by a communication with the water at the step of the lower mast, by means of a copper bolt driven through the keelson and keel; from thence it is continued along the back of the mast, in a small groove for that purpose, through and over the cap into the hole through which the top-mast slides, and thus again continued along the back part of the top-mast, and so on to the vane and spindle at the mast-head. That no discontinuity may occur, the back part of the hole in the caps has a copper lining, against which the sliding masts are made to bear, and to fill up the trifling vacancy in the caps, occasioned by the unequal size of the mast, when struck, a semicircular wedge, covered with copper, is placed between the copper lining and back of the mast; thus preserving a perfectly continuous conductor throughout. There is also, in case the top-gallant masts are on deck, a copper point screwed into the top-mast head, removable at pleasure, in order to produce a more pointed conductor.

By adopting this plan it must be apparent, that a vessel may strike her spars, and yet enjoy the security arising from perfect conductors; and if any injury should occur to the mast in any part, either from a press of sail or otherwise, the remaining portion will always protect the ship, by silently transmitting the lightning through the keel into the water, and thus

avoiding, in the midst of other dangers, the dreaded effects of this subtle and powerful agent; for it may be reasonably presumed, that the ship's masts furnished with such means, would, analogous with the points on the conductor of an electrical machine, transmit any quantity of atmospheric electricity without the least chance of accident:—a consideration of the highest moment, when we reflect on the repeated injuries which have occurred at sea to lives and property from severe strokes of lightning.

A similar experiment to which we alluded in the former part of this account, was made by Mr. H. in Hamoaze, on a larger scale, on Monday, the 9th September, for the satisfaction of the Navy Board: it was particularly interesting, not only as concerned the application of the conductor, but as affording a beautiful instance of the rapid transmission of the electric matter through water.

The remains of a small vessel, being fitted with a mast and top-mast, furnished with a small quantity of iron rigging to keep it steady, and a metallic communication with the water through her keel, was placed under the stern of the Caledonia, one of the first rates in ordinary: by means of a conducting line from the positive side of a battery which led through one of the cabin windows, the electric matter was conveyed to the mast-head, down a part of the top-mast (which was half struck) and lower mast, which was surrounded with two pounds of gunpowder mixed with detonating powder, then through the keel into the water in safety; from whence it found its way to a boat which was floating at more than 100 feet distance, under the influence of a strong ebb tide, and having a small gun on

board, by an electrical arrangement for the purpose, it discharged the gun in its passage, and then continued by means of another conducting line through the circuit to the negative side of the battery, whilst no sensible interval occurred between the discharge of the battery and report of the gun.

Since the publication of the preceding article, a correspondence on this very interesting subject has appeared in the Plymouth and Dock Telegraph, wherein Mr. George Harvey, whose general talents are highly appreciated in these towns and neighbourhood, but who, in this case, seems to have been carried by public zeal a little beyond his accustomed judgement, disputes Mr. Harris's claim to originality of invention, and quotes a passage from Mr. Singer's work on Electricity, in apparent confirmation of his opinion.

Mr. Harvey's conclusions must have been formed without due consideration;—we cannot suppose they were entertained by a spirit of detraction, for we are seldom induced to put unfavourable constructions on the arguments of others, because they are not exactly in consonance with our own; although in this case, Mr. Harvey has doubtless failed to substantiate a want of originality in the application of this discovery, which is in itself a most important invention.

The quotation alluded to (page 225-6, 1814) states that "conductors for ships have been made of chains, (which are highly improper,) and of copper wires, which are easily attached; but they are with equal ease detached: and I have been informed by several captains, that many ships furnished with such conductors, keep them in an inactive state, packed up below, during long and hazardous voyages. For this reason, it would be

better that fixed conductors should be used; they might, I should conceive, be attached to the mast; and where motion is required, an interruption might be made in the inflexible conductor, and its parts be connected together by a length of spiral wire, which would be at once perfectly continuous, and sufficiently flexible to yield to every necessary movement."

It must be obvious to every one at all versed in nautical affairs, that the conductors proposed by Mr. Singer, are as inapplicable as those objected to by him; for the spiral wires would not only run an equal risk of being displaced as those at first used, but they would entirely prevent striking the top-mast, &c. in a gale, or in case of the ship being stranded, and thereby create more danger than they are intended to avert. Now the excellence of Mr. Harris's invention is (to use the words of Dr. Cookworthy) "that it requires no flexibility, nor is it exposed to any of the evils that flexibility entails; it is permanently fixed throughout its whole extent; is perfectly continuous from the keel to the mast-head; and admits not only of every possible motion of one portion of the mast upon another, but of any part of the mast being removed either by accident or design, without having its continuity interrupted for an instant."

We congratulate Mr. Harris on the reputation he has acquired with those who are alive to the prosperity of science; and we hope that the reluctant half-admissions of his competitors in the same walks, will but stimulate him to be still more strenuous in those pursuits, which tend to the inventions or improvement, of creative genius. He has won our admiration, and "Palmám qui meruit ferat."

QUERIES

BY LIEUTENANT GREEN TO MR. HARRIS,

Concerning fixed Lightning Conductors.

How is the spindle in the truck, which passes six inches or more down into the body of the mast, to be prepared to prevent the electric matter from following it to the lower end,—from exploding there, and splintering the mast?

How is the spindle to be substituted when the top-gallant-mast is on deck in severe gales, when lightning is most severe and dangerous?

When the top-gallant-mast is on deck, the cap of the top-mast, which has much iron about it, is the highest point of the mast,—Is it possible to place the spindle in the cap, touching or near the iron, without its attracting the electric matter out of its course? The conductor connected with the spindle must lie across the cap and be in contact with all the iron about it.

If three conductors, such as the proposed, are efficient, how is it that a house should be set on fire, notwithstanding it was armed with eight pointed conductors, one placed to each chimney, extending four feet above their tops, and down into the earth? This occur- to Heckingham poor-house, near Norwich.

How is it that conductors of one inch and a half solid metal, are often much reduced in their substance by the effects of lightning, sometimes melted, at other times broken in pieces, and also expanded and become as hollow pipes?

If conductors, such as before described, can be so overcharged, broken, and melted, and the electric

matter become sensible in the form of a spark upon the outside of them,—is this not sufficient to shew, that it is a dangerous experiment to conduct electric fluid through a ship's *powder magazine,* and to fit the fleet as proposed?

How is it to be contrived, when the electric fluid is sensible in the form of a spark, on the outside of the conductor, and conveyed by it to the inflammable air in the bottom of a ship, to prevent their igniting and burning the ship?

How is the electric spark or sparks, which must, in very many instances form upon the outside of the proposed conductor, to be prevented from passing away and being conducted throughout the whole of the lower part of the ship, by the bilge-water, through which the conductor must pass?

What is to prevent the electric matter from being returned into the ship (provided it be conducted through the bottom) by the iron mooring-chains, which according to the present plan of mooring ships in ordinary, are directly under the fore-mast and bolt in the keelson placed to conduct the electric fluid into the sea?

How is the continuity to be kept up when the top-gallant-mast is struck and hanging in the mast-rope? At such times every roll or plunge of the ship throws the conductor placed in the top-gallant-mast out of the line of continuity with the one in the top-mast, nor is it possible, by any means I can devise as a seaman, to secure the top-gallant-mast at such times to the top-mast. It will not do to wedge the top-gallant-mast, because the royal pole will snap off by the jerks occasioned by the ship pitching, if the mast has not play. If the line of continuity is not kept up, the electric fluid must be

discharged from the heel of the top-gallant-mast directly upon the deck.

How is it to be presumed that conductors such as those proposed, can guard a ship from the effects of lightning, when it is well known that by the same flash of lightning a ship has had her mast two-thirds up from the deck shivered, the electric fluid at the same moment tearing up parts of the decks, also entering the starboard quarter, and after passing into the ship there destroying a bulk-head and doing other injury below?

When the proposed conductor becomes fully or overcharged by the electric fluid, which it may by a very trifling portion discharged from a cloud, what is to prevent the many hoops of the masts, and other iron in contact with the conductors, from attracting the fluid out of its course?

Is it possible to prevent the proposed conductors working out of the grooves?

What is to make up the deficiency of wood cut out of the masts to form the grooves?

Will not the water soak into and rot the mast in these grooves?

Is it possible to drive the hoops on a lower mast without the edges of the groove breaking in? In my humble opinion it is not possible to fit a mast after the plan of the model in the dock-yard, and plan proposed.

What will be the expence to complete the navy with such conductors, and to keep them in repair, without calculating that those now in use will be rendered useless? Upon the moderate calculation I make, it will require £500 to dock and complete each ship, or £6000 for every twelve ships.

How are the conductors to be placed to prevent the

electric fluid from passing into the three shieve-holes at all the royal-mast heads, top-gallant and top-mast heads, all of which shieve holes are lined with copper, the shieves and pins metal, as it is indispensably necessary the conductors be nailed to the lining of these shieve-holes? Will not this metal, (it being the greatest quantity,) conduct the electric fluid out of its course? may it not shiver all the masts, and no portion of the fluid pass down the conductor?

Should the conductor convey a portion of the electric fluid to the bolts in the keelson, which bolts are touching and encompassed with such a vast quantity of metal (copper upon the ship's bottom)—how is the fluid to detach itself from this mass of metal? and what will ultimately become of it and the metal on the bottom?

The spare top-masts and top-gallant-masts being fitted with the prepared conductors, and placed, as is the custom in all ships, between the fore and main-masts, pointing both to the quarter-deck and forecastle, on which the officers and many of the crew are always walking, will not all these men be killed by the electric fluid, should the lightning strike these longitudinal conductors, which it probably may, as well as the vertical ones? May not this discharge of fluid set the ship on fire?

What will be the fate of those persons who may place their hands upon the conductors when charged with electric fluid, as it is not possible for men in their duty to avoid touching them? will it not be instant death?

When the conductors are pregnant with electric matter, what will be the consequence should iron crow-bars, marline-pikes, or any other metal be placed against them: (nor is it possible to prevent this:)—will it not

be the means of discharging a proportion of the electric matter at the point such metal may be placed? If this be not the case, how are the conductors fitted to the ships in ordinary to be efficient?

Who in existence can truly say, what may be the consequence of so powerful an invitation as the three proposed conductors?

The proposed conductors are strips of thin copper such as ships' bottoms are coppered with, and cannot, at the higher part of the mast, or royal pole, exceed the breadth of one inch and a half; can it then be supposed that this small quantity of metal is equal to bear all the electric matter which may be discharged from a cloud, or that which the large spindle placed in the truck is equal to bear? Is it possible for the strip of copper to draw all the fluid from the spindle?

These strips of copper increase in breadth to four inches as they pass down to the lower, or largest masts; is this increase at all necessary, provided the beforementioned inch and a half of copper at the royal-pole (which is to bear the first and heaviest shock,) be efficient?

Will not the electric fluid ignite the tar, when it passes under the rigging at the mast-heads?

Will not the tar corrode the copper? and will not the rigging press so powerfully upon the slight metal as to displace it, and break off the line of continuity?

As the magazines, or parts about them, have much copper attached to them, and the hoops of the powder-barrels also copper, what will be the consequence, should the electric fluid so charge the conductor as for it to become sensible in the form of a spark on the outside, at the moment it is passing through the magazine?

MR. HARRIS'S REPLY TO LIEUTENANT GREEN.

[The reader is referred to page 37 when perusing this reply.]

To the Editor of the Nautical Register.

SIR,

If I have not hitherto replied to the questions in your journal respecting my application of permanent conductors of electricity to the masts of ships, it is because I considered that the proposer of them was evidently a person totally unacquainted with the laws of electrical action, consequently could never hope to afford him any thing like a satisfactory explanation, and not having either leisure or inclination to enter upon a useless controversy, I rather felt disposed to let my application rest on its own merits. Finding, however, that your correspondent, Lieutenant Green, perseveres in his observations, with that spirit and obstinacy which of necessity arises from a misapplied judgment, and being unwilling that he should consider my silence as a want of civility towards him, I will endeavour to show how very easily the queries which he has proposed may be answered.

Q. 1. How is the place of the spindle at the mast-head, &c.

Q. 2. Is of itself an answer to question 1.—How the iron on the caps is to be placed, to prevent *the power of attracting* the electric matter led by the conductor immediately in contact with it, particularly so when the top-gallant mast is on deck. THE CAP MUST THEN BE THE POINT OF ATTRACTION.

REMARKS.

Any termination of a ship's mast is virtually a point when opposed to many miles of electrified clouds, but since all applications admit of refinement in perfecting them, it is proposed to place a point on the top-mast-head, there being a contrivance for that purpose; and since the mast-head, as allowed by Lieutenant Green, is the point of attraction. The electric matter will consequently pass down the continuous conductor in contact with it.—See Singer's Electricity, page 150. History Electricity, by Dr. Priestly, page 162.

Q. 3. How the spindle (in the truck) &c.

A. The continuous conductor is placed there for this purpose. In Singer's Electricity, page 221, is an experiment which will fully establish its protecting effects in this way.

REMARKS.

At the Plymouth Institution, in the presence of Lieutenant Green, the following experiment was performed: The model of a mast was hollowed out, and filled with inflammable matter, communicating with the spindle at the mast-head; a conductor was placed along the back of the mast; it was struck by an electrical charge, and remained uninjured; but on the conductor being removed, it was shattered by an explosion.

Q. 4. How is it to be accounted for, &c.?

A. This question relates to the application of conductors to buildings, and therefore I refer to Franklin's letters, page 62 and 123; also Singer's and Cavallo's Elements of Electricity, page 224, and page 82, vol. i., also vol. ii. Appendix, page 283. If the conductors were not constructed as recommended in these different authorities, they were not efficient; the mere passing into the earth will not of itself preserve their action.

Q. 5. How a ship with a spindle, &c.?

A. *Because there was no efficient conductor.* See Recreations on Mathematics and Natural Philosophy, by Dr. Hutton, vol. i. p. 312.

Q. 6. How a man on board the *Salvador* should be killed by lightning, &c.?

A. Because the wet ropes which Lieutenant Green considers sufficient to protect ships from lightning, were not such good conductors as the animal body, the electric matter consequently passed through the man. See Hutton's Philosophical Recreations, p. 307, vol. i. Franklin's Letters, vol. i. p. 499.

Q. 7. How is it to be contrived, &c.?

A. The electric matter never becomes sensible in the form of a spark when passing through a continuous conductor.—Franklin's Letters, vol. i. p. 498, and 132.

REMARKS.

At the Plymouth Institution Lieutenant Green witnessed the following experiment:—The model of a mast fitted with the proposed conductor was surrounded with detonating powder, a violent electrical discharge was passed through it, and by an electrical arrangement, for the purpose caused to inflame other inflammable matter, after having passed through the former in safety. Lieutenant Green was also informed, that two years before, in the same place, one hundred persons, most of whom were then present, witnessed a similar experiment, when the lower mast and its conductor was surrounded with a bladder of hydrogen and oxygen gases, combined in the proportions which form water.

Q. 8. Unintelligible.

Q. 9. What is to prevent the electric matter, &c.?

A. When the electrical equilibrium is restored there is no further action.—Franklin's Letters, vol. i. p. 127.

REMARKS.

Suppose, after a body of water had escaped from a reservoir in the side of a hill, and found its level in the vale below, a person were to enquire what prevented its passing up the hill again in some other direction? Should we not reasonably conclude that such a person was quite ignorant of all the laws of gravity, and beseech him to inform himself respecting this principle with all convenient speed. Lieutenant Green surely cannot help perceiving the analogy between the two cases, and must at the same time admit, that if nothing would prevent the electric matter from returning by the moorings, nothing would prevent it going out again by the conductor, and thus he has a principle in action, which, with his accustomed ingenuity, he may employ for the purpose of producing *perpetual motion.*

Q. 10 and 12. relate to the particular method of applying the continuous metallic line to a ship's mast, as proposed by me, an account of which will soon be produced in a detailed form, when Lieutenant Green will perceive that every necessary consideration has been attended to.

Q. 11. What is to prevent the hoops about the masts, &c.?

A. An efficient and perfectly uninsulated conductor will never become charged. This question is similar to question 3, and has been already replied to.

Q. 14. is likewise the same, and is already answered. How is the conductor to be placed to prevent the electric fluid passing into the shieve-holes, &c.?

Q. 13. What will be the expence to complete the Navy, &c.?

A. The expence will be insignificant, and certainly at its greatest, not so much as the life of one man is worth.

Q. 15. Is but a repetition of some of the preceding ones: the answer to it is seen under questions 10 and 12, and also under questions 3 and 5.

Before concluding, I am induced to request Lieutenant Green will reflect on the many inconsistencies which appear in his communications on this subject. In those of the 20th of October, and the 11th of December, he—

1st. Descends to personal reflections for the purpose of raising certain views of his own in the public estimation, and without any other excuse for so doing; now, to employ unhandsome and unjust insinuations, not only as relates to me, but also to the highly honourable Board who have noticed my application, is, to say the least, very unphilosophical, and should never have attended a difference of opinion.

2d. He states that my plan of fixed conductors to ships *is not original,* because he *had a plan* some years since, but which, by his own account, is not at all like it.

3d. He describes a part of his application as having an exclusive action at the top-gallant-mast head, and yet proposes questions 1 and 2.

4th. He says, in allusion to pointed conductors, and in opposition to the long established and consistent opinions of the most eminent men, "that it is dangerous to invite lightning to ships and buildings;" yet he proposes question 1.—Franklin's Letters, vol. i. page 170 and following.

5th. He considers the present chains and ropes as the only necessary protections against strokes of lightning on ship-board; and yet has proposed to rig a ship in a peculiar manner, and place certain incomprehensible conductors about her, which by his own account are totally unnecessary.

6th. He says, in allusion to my lecture on the subject of atmospheric electricity at the Plymouth Institution, "that he came to meet a jury placed to support me under all circumstances," although I was not personally acquainted with more than 40 persons out of 130 who were present. Is it not both uncourteous and unphilosophical to libel (in this way) a set of gentlemen, many of them officers in the British Navy, highly distinguished for their honour and liberality, merely because they expressed their unqualified disapprobation of his (Lieut. Green's) mistaken views of the question?

7th. He states that he came unprepared for any discussion, and yet had proposed the queries in the *Plymouth Telegraph,* nearly a fortnight before.

8th. He complains that his questions remained unanswered; when he heard a lecture which expressly included the point in question, and witnessed the experiments described under questions 3 and 7.

This is uncandid as well as inconsistent.

He details the case of a ship under the influence of a thunder-storm, and which, evidently received protection *from a conductor,* to prove "the impossibility of guarding ships effectually in this way."

He says "Dr. Franklin proves that lightning burns, dissolves metals, rends some bodies, &c.; but he forgets to state, that the same illustrious philosopher proves that a continuous conductor will prevent such effects.

After all these manifest contradictions, and the many evidently unscientific questions which he has advanced; he proposes to write a pamphlet on electricity.

There are many other extraordinary anomalies in his communication, beside some incomprehensible matter relating to what he terms the *literal explosion*, the additional passage of an electrical atmosphere discharged from a thunder-cloud, &c.; but compared with this last, which I esteem as the acme of all perfection in absurdity, they may be considered nothing.

Now, Sir, I appeal to the candour of your readers, and to Lieutenant Green himself, if such inconsiderate statements are not enough to deter me from any further correspondence, I must therefore beg leave to say, that as this is the *first*, so it will be the *last* of my communications with that gentleman; and that I leave him to pursue his schemes with all the ingenuity of which he is capable; and that when he can demonstrate their utility either by fair reasoning, or by actual experiment, I shall be happy to acknowledge it.

I am, Sir,

Your very obedient Servant,

WILLIAM SNOW HARRIS.

ELECTRICAL EXPERIMENT OFF SOMERSET HOUSE.

[From the Nautical Register Newspaper.]

An experiment was tried before Somerset House, in the presence of two of the Lords of the Admiralty, the

Comptroller of the Navy, Navy Board, and others, for the purpose of obtaining additional proof of the practicability of the plan adopted in the navy, of fitting their masts with conductors for lightning, after the manner of His Majesty's ship Java, which met with the decided approbation of all present, and must be highly gratifying to the inventor. A cutter, fitted for the purpose, (previously brought from one of the dock-yards,) was moored in the river: a conducting chain, extending from one of the windows of a room in the house, (in which was the electrifying machine,) to the top of the mast; the electrical fluid was, by this, passed from the house to the conductor in the mast, and the experiment fully succeeded. [This paper also quotes the remarks from the Plymouth Telegraph, inserted at page 72.]

Repeated experiments were also made in a room at Somerset House, and at the Plymouth Institution; for which purpose a ship was built, rigged, and in every way completed, with the exception of a copper bottom and iron about the caps, &c. and placed to float in water in the room; shewing the exact resemblance of the first experiment made on the water at Plymouth, previous to fitting H. M. ship Java, and preparatory to this plan being generally introduced into the navy.

REMARKABLE ALTERATION PRODUCED IN WOOD BY LIGHTNING.

[From The Chemist.]

In a letter sent from Griefswalde, of the 22d of November, 1822, to Mr. Bergrath Lenz, the following cir-

cumstances are related :—In the year 1821, in the month of August, the lightning set fire to a windmill, situated near Griefswalde, and damaged several of the arms of the mill. The miller, on going to repair his mill, found in the axletree an aperture in which he discovered 280 black balls, all of the same size : some which were found under similar circumstances, near Thoren, were considerably larger. This letter was accompanied by one whole ball and a half one. The half ball was given to the writer of this notice for examination. It had the shape of an elliptical spheroid, the large axis of which is 18, and the small axis 17 parallel lines. Their substance is of a dark grey colour, and not porous, of a brittle texture, and containing small, hardly perceptible particles of wood. On the surface, it appeared flaky. In a chemical point of view, it appeared partly like brown coal, partly like burnt wood ; for with ammonia, and still more easily with solution of potash in water, it may be dissolved into a dark brown fluid, with the exception of the particles of wood; and when exposed to a current of air, and sufficiently heated, burned at first with a flame, and afterwards glowing, by which process the usual products of burnt wood, namely, carbonic acid water and an alkaline ash were formed. The substanceof these balls, therefore, is nothing but the wood

the axletree in which they were found, crushed, half burnt to cinders, melted, and at last formed into balls by the lightning. The circular form which they all had is undoubtedly the most remarkable circumstance of the whole event, and deserves the attention of natural philosophers.

VITREOUS SAND TUBES.—POWER OF LIGHTNING.

[From the Chemist of March 27.]

In 1812, E. L. Irton, Esq. of Irton Hall, Cumberland, transmitted to the Geological Society, specimens and descriptions of some tubes found in the sand near Drigg, in Cumberland. Three were found, and the diameter of each was about an inch and a half. The spot was afterwards examined, and the substances subjected to a chemical examination, by some of the members of the Geological Society. From their examination and experiments, it resulted, that these tubes had been formed by the passage of the lightning or electric matter through the sand, which it melted or fused in its passage into the earth. These tubes were found to descend about 30 feet through the sand. The outside of the tube was coated with an agglutinated sand, which, when viewed with a lens, was found to consist of black and white grains mixed together, rounded by fusion. The sides of the tube were about the 20th part of an inch thick, very hard and rigid, and the outside interrupted by deep furrows, like the bark of an elm-tree. On one spot in its descent, the electric fluid had met with a bed of pebbles of the size of kidney beans; and dispersed and spread its fusing power, so as to form, not a tube, but a mass. In one place, about three feet under the surface, it had made an attempt to pass between two large pebbles, which flattened and lessened the tube; and immediately below this it became crooked and contorted. The following accounts of some similar discoveries were published in the *Annalen der Physik* for June and July,

1823 :—"I was," says Dr. Charles Gustavus Fiedler, in Stampfen, on the borders of Hungary; and having procured the assistance of some of the inhabitants who could speak German, I set out, examining the neighbourhood in search of a vitreous-sand, or lightning-tube. After much trouble, I at length found one, and the first which has been discovered in the dominions of the Emperor of Austria. The place where it was found was the highest point of a low sand-hill, about half a league from Zankendorf, near Malaczka, in a northerly direction. The upper part of the tube was nearly half an inch in diameter, from which I concluded it would sink very deep. After we had dug down about two yards, we came to a layer of pebbles, and then to a layer of clay, below which I was sure the electric fluid would not have penetrated. At first it had taken a slanting, and afterwards a perpendicular direction. Six inches below the surface, a small branch, four inches and a half long, went off from the main tube; and at the depth of 32 inches, the tube divided itself into two branches. These branches terminated on the clay, one being seven inches and a half long, and the other nine, owing to the surface of the clay not being even. Below the tubes the traces of electricity, scattered over the clay, were visible, and it appeared as if it had been exposed to the action of fire. Immediately below, where the tube split into two branches, a large pebble was found, which was, probably, the cause of the division."

In the July number of the *Annalen,* a Mr. Hagen, Professor of Chemistry at Konigsberg, gives an account of some peasants observing the lightning to enter the earth, on July the 17th, near the village of Rauschen, on the borders of the Baltic. They found two holes close to a

high tree, where they saw the electric fluid descend, and the earth was hot all round the spot. On a closer examination, about a foot below the surface, immediately under one of the holes, a tube was formed, and parts of it found. It was, however, very thin, giving reason to believe, that the stream of electricity was not, in this instance, so great as in some of the others; and the outside was covered with black dust, which in its properties resembled charcoal.

This latter account is of considerable importance, as confirming the conjecture that these tubes are caused by lightning. Hitherto this was only conjecture; but we may now set it down as fully ascertained. We may remark, in closing this article, that this fact furnishes another proof of the great benefits which may be expected to result from imitating, by art, the processes of nature, whether the object to be accomplished, is to add to the mechanical power, or to the chemical knowledge of man. In this case we have an example of the instant passage of electricity fusing one of the most infusible of substances: thus we are taught, that electricity may be used as a powerful instrument of chemical analysis; and we know that, following up this instruction, the galvanic battery has already been applied to extort several secrets from Nature.

PREVENTION OF THE EFFECTS OF LIGHTNING.

Men are very rarely struck by lightning. It seems to avoid them, and attach itself to more attractive and

larger objects; unless arrested in its course by some metals on or near the person.

When persons happen to be overtaken by a thunder-storm, although they may not be terrified by the lightning, yet they naturally wish for shelter from the rain which usually attends it, and therefore, if no shelter be at hand, generally take refuge under the nearest tree they can find; but, in doing this, they, unknowingly, expose themselves to a double danger,—first, because their clothes being thus kept dry, their bodies are more liable to injury, (the lightning often passing harmless over a body whose surface is wet,) and, secondly, because a tree, or any elevated object, instead of warding off, serves to attract and conduct the lightning, which, in its passage to the ground, frequently rends the trunks or branches, and kills any person or animal that happens to be close to it at the time. Instead of seeking protection, by retiring under the shelter of a tree, hayrick, pillar, wall, or hedge, the person should either pursue his way to the nearest house, or get to a part of the road or field which has no high object that can draw the lightning towards it, and remain there until the storm has subsided.

It is particularly dangerous to stand near leaden spouts, iron grates or palisades, at such times; metals of all kinds have so strong a conducting power for lightning, as frequently to lead it out of the course which it would otherwise have taken.

When in the house, avoid sitting or standing near the window, door, or walls, during a thunder-gust. The nearer you are placed to the middle of the room, the better.

Ensign Cogan, of the 68th Regt. on the 9th June, 1824, while standing at a window of a house in Quebec, was struck by lightning and killed on the spot.

The greatest danger to be apprehended from lightning is the explosion of powder magazines: which might, in a great degree, be secured from danger by insulation; or by lining the bulk-heads and flooring with materials of a non-conducting nature, the expence of which would not be great.

When a person is struck by lightning, strip the body and throw buckets-full of cold water over it for ten or fifteen minutes; let continued friction and inflation of the lungs be also practised; let gentle shocks of electricity be made to pass through the chest, when a skilful person can be procured to apply it; apply also blisters to the breast.

REMARKS ON THE EFFECTS OF LIGHTNING CONDUCTORS.

Professor Richman was in the act of making experiments: he had placed a conductor at the top of his house, to which he had fastened a chain; this he conducted to his chamber. The conductor was affected by the lightning, which passed down to the Professor; a person near him saw a globe of blue fire, as large as his fist, jump from one of the rods affixed to his apparatus towards the head of the Professor, which killed him on the spot; he was at that instant a foot distant from the rod,—the metal chain was broken in

pieces, the door of the chamber torn off the hinges, and much other damage done to the house: many persons outside declared they saw the lightning shoot from the cloud to the conductor at the top of the house. This surely bears me out in what I have asserted, that ships are better without conductors;—had there been no conductor to the Professor's house, the lightning would not have been attracted and would have passed over his house, as it did others in the town, without exploding.

His Majesty's ship Perseverance, Capt. J. Smith, while off the sand-heads, Bengal-bay, was struck by lightning in the eye-bolt at the end of the fore-top-gallant-yard, burning part of the yard to a cinder: from the yard it shot to the iron about the fore-cap, entered the fore-mast-head, splintering the fore-mast (which was woulded by rope and not hooped with iron as is now the case) as far down as about six feet from the fore-castle-deck; from thence it passed over the forecastle into the sea, killing one man who came in contact with it—he was burnt to a cinder; several other men were dreadfully scorched. *At this time both conductors were up*, neither of which appeared to convey any of the electric fluid into the sea.

In the year 1802 His Majesty's ship Cleopatra, Capt, now Admiral Sir I. Pellew, was at anchor off Vera Cruz; early in the morning it began to rain, accompanied by thunder and lightning; the rain increased to torrents, and such were its effects on the ship that the hatches were battened down and the pumps obliged to be kept working all night; the captain's cabin was overflowed.

The vivid flashes of lightning which searched every crevice were without intermission, and continued so during the whole of the night. The sky was in flames with lightning; the clouds heaped upon one another, reflecting the most terrific hues, more or less vivid as they were more or less opaque, while the whole appeared so closely embodied round the ship, that it seemed as if she was in the very bosom of a volcano. The electric fluid ran down the whole of the rigging, having the appearance of blue fire, and as squibs of powder to exhaust itself. A conductor was hoisted at the mizen-mast-head; from the lower end of it the electric fluid continued to dart into the sea. During the progress of the storm, though the lightning continually struck the ship the same cloud was the next moment ready to make a still greater discharge and the ropes continued to be as much affected as before, so that the clouds must have received at one part in the same moment when a discharge was made from them in another.

His Majesty's ship Kent, Capt. Rodgers, in the Mediterranean, was struck, three men were killed and several wounded, the top-gallant masts were splintered, the top-masts much injured, the hoops of the masts twisted and broken. *At this time the conductors were at the mast heads*, and there were more than twenty sail of His Majesty's ships in company, without conductors, none of which ships were injured.

Heckingham poor-house (near Norwich,) was set on fire by a stroke of lightning, notwithstanding it was armed with eight pointed conductors. This house had eight chimnies: to each chimney conductors were

affixed, reaching four feet above the top of the chimney, and down to the earth.

The *Perseverance* coach, on its way from Boston on the 14th of July last, at 11 o'clock in the morning, was struck by lightning: three of the horses fell, and the coachman was much injured, as were also several gentlemen on the outside. All those who were behind and had up their umbrellas and were much injured by the electric fluid; while those not having them, and who were on the front part, escaped unhurt. It is evident in this case, that the metal points attracted the electric fluid, which was also drawn to the ornaments of the harness. This is not the first time that I have known umbrellas to occasion such fatality. Why not then use ivory or bone in mounting the tops of umbrellas or parasols? A very proper comparison may be made between the ferrule to the umbrellas and the spindles of the fleet at Plymouth. Some of the umbrellas were broken in pieces; thus proving, that it is dangerous to invite lightning. The gentleman who was the greatest sufferer informs me, that his umbrella was broken in pieces, and he threw it away; and that his hat was rendered useless, the buckle being carried off or melted: he did not examine the ferrule to see the effect the lightning had upon it. The coach at the time was on a hill.

M. D'Alibard prepared an apparatus at Mary-la-ville, near Paris, for the purpose of attempting the experiment proposed by Franklin, for bringing lightning from the clouds: it consisted of an iron rod, forty feet long, the lower extremity of which was brought into a sentry-box, where the rain could not come; while on the outside it

was fastened to three wooden posts by long silken strings defended from the rain. In his absence, he entrusted the care of the machine to one Coissier, a joiner, a man of sense and courage, whom he furnished with directions to proceed in case of a thunder storm. On the 10th of May, 1752, between two and three in the afternoon, Coissier heard a clap of thunder. He ran to the apparatus, for D'Alibard was then absent, and drew sparks from the rod, in the presence of several witnesses.

PHÆNOMENA.

A most extraordinary phænomenon occurred at the island of Java, in 1772. On the 11th of August, at midnight, a bright cloud was observed covering a mountain in the district called Cheribau, and several reports like those of a gun were heard at the same time. The people who dwelt upon the upper parts of the mountain, not being able to fly fast enough, a great part of the cloud, about eight or nine miles in circumference, detached itself under them, and was seen at a distance rising and falling like the waves of the sea, emitting globes of fire, so luminous that the night became clear as day. The effects of it were astonishing; every thing was destroyed for twenty miles round; the houses were demolished, plantations were buried in the earth; and 2140 people lost their lives; besides very many herds of cattle, goats, horses, and other animals.

This, and other circumstances, teach us to believe, that there is some other agent concerned in the formation of clouds, besides mere heat and cold; this agent is electricity,—not only in the formation of clouds of

every description, but in producing hail, snow, or rain. It is certain, that the clouds which are formed by atmospheric vapours, whether they be rendered visible by electricity or not, contain prodigious quantities of electrical fluid, which frequently produce the most disastrous effects.

At Quesnay, the weather being very cloudy, a cloud, which seemed to touch the houses, emitted a globe of fire, which broke itself against the tower of a church, with a report like that of many cannon, and spread itself over the town like a shower of fire.

In France (near Brest) were seen three globes of fire, of three foot or more, diameter each, and they were united together. This large vortex of flame came rapidly down, and pierced through the church, two feet above its level with the ground, killing four persons who were ringing, and made the walls and roof of the church spring as a mine would have done; so that the stones were scattered round about, some of them being carried twenty-six fathoms, and others sunk more than two feet into the earth.

At Hogue in Lower Normandy, a fire was observed in the air having the shape of a tree, and seemed to fall and lose itself in the sea with a noise which made two large villages tremble.

In Lower Bretany, in the evening, on that part of the coast which extends from Landemeau to St. Paul of Leon, 24 churches in which the bells were ringing were struck by lightning, while many churches near them in which there was no ringing, was spared.

In August, 1823, between twelve and one o'clock in in the day, a most singular phænomenon was witnessed by many of the inhabitants of Margate. The clouds highly impregnated with electric matter, commenced an awful discharge about three miles from the harbour; the fluid descended in a serpentine manner from the atmosphere to the sea in regular streams of most vivid lightning, diffusing a light at once brilliant, awful, sublime and interesting. The discharge continued for nearly half an hour before the generation of the rain which subsequently descended in torrents.

EFFECTS OF LIGHTNING.

Much has been said, of late, in the newspapers, concerning the effects of lightning, particularly in Canada; but the statements invariably detail the *effects* only. This is much to be lamented, because a proper enquiry into the *cause* of any particular house, ship, or man's being struck, thus laid before the public, would have a tendency to induce persons to use the proper means of evading danger. I am of opinion that lightning seldom strikes any building or man without being attracted by some metal; and that persons who are hurt or killed by it, have metal buttons, or (as has been before observed,) are near some metal or other powerful attractive. Windows, therefore, (which are non-conductors,) should be closed in time of lightning; and all metal, such as fire-irons, &c. should be removed to some closet.

On Wednesday evening July 14, several very heavy storms of thunder and lightning visited London. About one o'clock in the afternoon, Enfield, Waltham Cross, Cheshunt, and their vicinity, felt the severest. It was accompanied with thunder, lightning, and torrents of hail. The devastation occasioned by the latter was very great, some of the stones being of the dimensions of pigeons' eggs. The grounds of H. Meux, Esq. of Theobald's, suffered considerably; nearly 100 panes of glass were destroyed. A sawyer was knocked down by the electric fluid entering his hand, which it severely lacerated, and then passed off through the saw into the earth, without doing further mischief. Several panes of glass were broken at the Great Bull Cross. The lightning has seldom been seen so vivid as it was that night, or the rain to fall in heavier torrents in the metropolis. The storm was most violent in the middle part of the county of Kent; it entered from Sussex, and passing over the entire weald of Kent, Canterbury, and the towns on the sea-coast, discharged an immense quantity of water, stopping the passage of many bridges and public ways, and laying the low lands under water, spoiling and carrying away vast quantities of hay and seed-grass. The extreme breadth of the clouds appeared to be about 20 miles. The river *Stour* rose rapidly in a few minutes, and the ditches were insufficient to carry off the water. Margate suffered severely, but at Ramsgate the flood rose to such a height near the market-place as to lay the cellars under water. At Walsham two trees were shivered by the lightning, and the cellars were filled with water to the depth of many feet. A fire-ball fell at Rickinghall, and the house of Mr. Smith, butcher,

was also struck by the electric fluid, which passed down the chimney, and knocked down the man and two children in the room. Mr. Smith was long in a state of insensibility, but the children were not injured.

An account of a meteoric stone, said to have fallen near London, having appeared in the newspapers, it may be proper to offer some hints on the formation of substances of this description.

It is supposed that suitable matter is drawn from the earth and sea (say, charcoal, sand, gases, salt, &c.) and collected in the air, to form balls, and other masses similar to the above. This matter, when the heat becomes great, vitrifies. A mass of mineral may be subjected by heat at once to three processes of melting, calcining, and vitrifying; and this is because the caloric finds metallic particles to melt, sands to vitrify, and earth to calcine. Heat hardens some bodies by evaporating the moisture from them, as is evident in the making the common dark clay marble, which, in its nature, is similar to what is called a *thunderbolt*. This operation is also performed by the air or wind, which alone dries and burns up grass and other substances, because it carries away the moisture, and consequently hardens, not only the surface, but the whole body.

On August 19, 1824, a thunder storm burst over Fountains Town, in Ireland, near the residence of Geo. Hadder, Esq. One peal was tremendous, and its effects have been severely felt. Five labouring men had taken refuge in the house of a farmer; the electric fluid penetrated it, scorched the labourers in the most dread-

ful manner, and cut a dog across the back: a child, who lay in a cradle, escaped unhurt. The men were all speechless, but hopes are entertained of their recovery.

America.—A New York Paper, of the beginning of July, has the following account of a storm, which had just visited the town of Portsmouth:—"On Wednesday, last week, a storm occurred at Portsmouth, New Hampshire, which, from all accounts, was one of unusual sublimity and grandeur. Two children were killed in a school-house at Rye. One young man was killed in the garret of a house, about a mile distant from the school-house. More than half of the children were knocked down, and many were stunned. On Saturday se'nnight there was a storm at Pittstown: The lightning struck the house of a Mr. Shea, broke the reach pole, came through the roof, and killed Mrs. Shea, who was walking the floor with her child in her arms. The child was not hurt. A scythe was hanging directly over her head when the lightning descended.

July 26, 1824.—On the night of the 14th inst. the lightning struck the Cathedral of Strasbourg, melted the lead which cemented several stones, and destroyed the sound of the largest bell.

An English brig, off the Isle of Wight, in Dec. 1823, was struck by lightning in the fore-top-mast-head, which splintered the mast, knocked the four men off the top-sail yard to the deck, killed one man; all the others were dreadfully burnt. The fluid passed through the boat, from thence to the taffrail, passed through it, burning the boat.

A paper from M. Nicholson, Esq. contains a very uncommon example, in an accident which occurred at Mr. Chadwick's house, about five miles from Manchester, on the 4th of September 1809. A very loud explosion of thunder took place, and the front wall of the coal vault, containing about 7000 bricks, and weighing 26 tons, was gradually lifted up. Mr. Henry compares this to the thunder-storm at Coldstream, described by Mr. Brydone in the Philosophical Transactions for 1787, and explained by Lord Stanhope. He conceives it to have been a case of the returning stroke. The lightning he supposes to have issued out of the earth by the coal vault, to restore the equilibrium in the clouds over head.

In a violent thunder and lightning storm, a quantity of wheat and rye, fit for shipping, in the stores at Dantzic, was discovered, the day after the storm, to have lost all its good qualities, and become clammy and stinking: it required airing for three weeks before it recovered.

This is a thing said often to happen to corn that has not lain in the granary a whole year, or not sweated thoroughly in the straw, before it was thrashed out. The cause of this accident is worthy of enquiring into.

St. Bride's church, Fleet street, London, was struck by lightning. A bar of iron as a supporter to the top of a window was broken. An iron bar was inclosed, nine inches deep in the stone work of the pier, separating the left arch from the arch next it: towards the north, the end of this bar joins, at right angles, another bar, which is laid across the arch.

The lightning accumulated in the iron part mentioned, which was inclosed in the stone work, bursting off all the stones that surrounded it, and part of the pier adjoining. The flaw is continued downwards, meeting with smaller iron cramps in its way. At the next arch, lying immediately under the last mentioned one, an iron was inclosed in the stone, in the same manner as the bar before mentioned: the stone is burst from the sides of this iron in the same manner as in the first instance. At the bottom of this arch, the cill-stone, which covered some cramps of iron, is torn off from its place, and other damage done. In every part that is damaged, the lightning has acted as an elastic fluid, endeavouring to expand itself when it was accumulated in the metal, and the effects are exactly similar to those which would have been produced by gunpowder pent up in the same places, and exploded. It is a well authenticated fact, that lightning burns, dissolves metals, rends some bodies, strikes persons blind, destroys animal life, and deprives magnets of their virtue, or reverses their poles.

H. M. ship Hyperion, Capt. Killicrop, off the Moro, with a convoy, experienced very boisterous weather, and it was so dark, accompanied by heavy thunder and lightning, with such torrents of rain, never before witnessed by any of the fleet, that it was only at short intervals the ships could get a glimpse of each other; and they were six successive days without an observation of any sort.

Captain Dibdin of a Merchant ship states the effect of lightning as follows:—At Martinico, a violent flash of

lightning made an opening in the wall under which he and others took shelter, about four feet high, and three feet broad; he observed, on entering the hole, that a square bar of iron one inch and a half thick, near the hole, which joined another bar an inch thick, had been struck by the lightning, and were wasted in their thickness in some places very considerably, insomuch that it looked like a burnt poker which had been long in use; the bar was broken into two pieces; parts of the bars were changed in colour to a grey or whitish hue, resembling iron after it had been exposed in a violent heat and suffered to cool; one of the bars touching the wall, had undergone an extraordinary change, the end next the wall being reduced from one inch in diameter, to the size of a slender wire, but tapering towards the wall.

On Tuesday, 28th of June, 1761, about an hundred leagues west from the Land's End of England, the ship Eustatia received a most violent shock, accompanied with a prodigious noise like a thunder-clap, which shook the vessel so excessively, that it was feared she would instantly founder; in this concussion the foremast and bowsprit were carried away; however, providentially, in about three minutes the waters appeared calm and settled, and for two days the weather continued serene, by which the hands were enabled to refit. In our course to this harbour, abundance of masts, sails and yards were observed floating; whence we suppose several weak vessels to have been destroyed by this terrible convulsion, and consequently many lives lost.

On Tuesday 28th July 1761 the sea was observed to flow at Plymouth upwards of eighteen inches, in about two minutes, and immediately to ebb with the same rapidity. This extraordinary flux and reflux was the more surprizing, as it continued the whole day. It is supposed to have been occasioned by earthquakes somewhere.

By a letter from Ross, in the county of Wexford, we are informed that, the same day, the wind being calm, about seven in the evening there was a violent commotion of the water in that river, which forced a sloop from her hawser, and the ferry-boat on her passage turned round with great velocity. It returned in the usual course like a sluice.

From Waterford we also learn of an agitation in that river, where the sea rose thirty feet extraordinary, though it was near the last ebb quarter.

We also hear from Penzance that the day was uncommonly hot, and very calm; and that the water was agitated in an uncommon manner. Sometimes it would run in past its usual bounds, and return again with great swiftness, and continued in this manner most of the afternoon. Towards evening the horizon began to be cloudy, attended with thunder and lightning; and at half past seven there was the fiercest flash of lightning attended with the loudest clap of thunder ever heard. At Ludgvan, about three miles from Penzance, the lightning struck down one of the pinnacles of the tower, forced in one side of the porch, passed into the church, and shattered the pulpit and canopy, threw down one of the tables of the commandments at the altar, and did a great deal of other damage. It is ima-

gined that if the tower had not been a very strong built one, it would have been laid in ruins.

On 1st August, 1761, at six in the evening, there was a most terrible storm of lightning, thunder, and rain at Sowerby, near Halifax; the whole town was, by the thunder agitated in dreadful manner, which threw the inhabitants into the utmost consternation; many were thrown down, several sheep in an adjoining croft were scorched to death by the lightning, part of the wool was burnt and torn off, but they had no other marks of violence appearing on them. The ground in many places was forced up as with a plough; in others many surprising apertures were made in the earth, which seemed to be of an astonishing depth. The lightning penetrated into one house in particular, tore up the pavement, and many of the pieces hit the dwellers on the legs and shoulders; but, through the mercy of God, not one in the town received any capital damage.

At Cumbernauld, in Scotland, in July 1761, there was a violent storm, attended with thunder and lightning, which did considerable damage to some plantations, and killed above 1000 cows. Upon examination, all their bones were found broken, their flesh quite black, and when offered to some hogs, they could not be prevailed upon to touch it.

Professor Lapostolle, of Amiens, has discovered that straw possesses the quality of serving as a conductor to lightning and hail. Repeated experiments have

convinced him that straws united together, serve equally well as the iron rods now fixed upon buildings, for the former purpose, at the same time that they are not attended with similar inconvenience. In consequence of this discovery, the common buildings may be secured from the effects of lightning in the most economical manner; and even crops on the land may be protected from the ravages which they sometimes suffer from hail.

Printed by Taylor and Green, 1, Rood Lane, Fenchurch Street.

LIST OF WORKS,

BY THE SAME AUTHOR,

Referred to in the Introduction, but not Published.

1.

A COMPARISON between the respective FORCES of HIS MAJESTY'S SHIPS and those of AMERICA; stating the probable result, if they should ever engage in battle: including Remarks on the Defective State of the Discipline in the Navy, &c. &c. Transmitted to the Commander in Chief at Halifax, Nova Scotia, 1808.——Received the Thanks of the Admiral.

2.

INSTRUCTIONS for TRAINING the CREWS of our SHIPS to the Use of Arms, in Attack and Defence, &c. &c. Illustrated by Plates.——Thanks of the Admiralty, 1812.

3.

REVIEW of JAMES'S Account of the late American War; illustrated by 17 Plates of the battles: in 15 of which, the Americans were victorious.

4.

BRITISH NAVAL ECONOMY; illustrated by Plates. This includes a New System for Rigging Ships, either at Sea or in Harbour, without Stripping the Masts, and for speedily replacing Shrouds in time of Battle; also, a Plan for Reducing the Size of all the Ropes and Rigging in His Majesty's Ships: with a Review of Mr. URQUHART'S able Letter on Impressment and Manning the Navy, &c. &c. &c.——A Medal presented from the Society of Arts.

5.

IMPROVED PLAN for FITTING and FIGHTING CANNON; which enables two, three, or four Men, to work any sized Gun with greater facility than by the present mode: including an improved Staff for the Rammer, &c. calculated to supply the place of the four now in use; with other Improvements. Illustrated by Plates.——A Medal presented from the Society of Arts.

6.

A Cheap and Efficacious PROCESS to prevent DRY ROT; by which any Green Timber is rendered in one day, as durable as old or seasoned Wood; and, when so prepared, is not liable to be attacked by Worms, or Dry Rot. Including Hints to Builders, and a comparison of the advantages and disadvantages of Diagonal and Longitudinal Decks, Spiral Wheels, short Tillers, and tapered or reduced Rudders, &c. for Ships. Illustrated by Plates.

7.

REMARKS on the NAVAL POLICY of the BRITISH EMPIRE.

8.

SCHEME for Establishing a FUND for the Relief of Indigent WIDOWS and ORPHANS of Deceased OFFICERS, of every Class; entitled, the NAVAL UNITED BENEVOLENT INSTITUTION; *which is now established.* On the *National,* as well as private advantages of this Institution, volumes may be written. Out of this has grown a similar Fund, confined to a particular class of Officers only; entitled, the NAVAL ANNUITANT SOCIETY.

9.

A Series of LETTERS and other PAPERS, giving an account of the Movements of the Fleets on the Lakes in Canada; shewing the species of Stores sent there, and how the same were diposed of.